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ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

NAVAL WEAPONS STATION YORKTOWN, CHEATHAM ANNEX
(a/k/a NAVY WEAPONS STATION YORKTOWN-CHEATHAM ANNEX)
WILLIAMSBURG, YORK COUNTY, VIRGINIA
EPA FACILITY ID: VA3170024605
SEPTEMBER 7, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

NAVAL WEAPONS STATION YORKTOWN, CHEATHAM ANNEX
(a/k/a NAVY WEAPONS STATION YORKTOWN-CHEATHAM ANNEX)

WILLIAMSBURG, YORK COUNTY, VIRGINIA

EPA FACILITY ID: VA3170024605

Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. (The legal definition of a health assessment is included on the inside front cover.) If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E60), Atlanta, GA 30333.

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List of Abbreviations

AOC	area of concern
AST	above-ground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
CAX	Cheatham Annex
CEL	cancer effect level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CREG	cancer risk evaluation guide (ATSDR)
CV	comparison value
EMEG	environmental media evaluation guide (ATSDR)
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
FFA	Federal Facilities Agreement
ft	Feet
IAS	initial assessment study
IDA	Industrial Development Authority
IRP	Installation Restoration Program
LOAEL	lowest-observed-adverse-effect level
MCL	maximum contaminant level (EPA)
MRL	minimal risk level (ATSDR)
N/A	not available
NFRAP	no further remedial action planned
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
NPS	National Park Service
NTP	National Toxicology Program
NWS	Naval Weapons Station
PAH	polycyclic aromatic hydrocarbon

List of Abbreviations

PCB	polychlorinated biphenyl
PHA	public health assessment
ppb	parts per billion
ppm	parts per million
RBC	risk-based concentration (EPA)
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfD	reference dose (EPA)
RI	remedial investigation
RMEG	reference media evaluation guide (ATSDR)
ROD	record of decision
SARA	Superfund Amendment and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	site investigation
SOC	synthetic organic contaminant
SVOC	semi-volatile organic compound
TNT	2,4,6-trinitrotoluene
UST	underground storage tank
UXO	unexploded ordnance
VDEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
VIMS	Virginia Institute of Marine Science
VOC	volatile organic compound

Summary

Naval Weapons Station Yorktown, Cheatham Annex (hereafter Cheatham Annex or CAX) is located in York County, Virginia, outside of Williamsburg. It opened in 1943 and has been used for bulk storage and overseas shipping.

During World War I, much of what later became CAX was used for the Penniman Shell Loading Plant and an ordnance depot. After the war, the facilities and remaining shells were decommissioned. In 1926, the property was sold to a private owner. Unfortunately, records from the Penniman era are incomplete and it is not known how some of the materials were taken out of service. Explosive materials or shells could still be buried somewhere in this area. None of the investigations conducted to date have identified ordnance that could pose an explosion hazard at any CAX site. However because of the uncertainty about the disposal of the Penniman ordnance-related products, the U.S. Environmental Protection Agency (EPA) continues to search for information about the past operations and disposal practices.

The Agency for Toxic Substances and Disease Registry (ATSDR) reviewed available information about the historical and current use of the sites, environmental sampling, and remedial actions. Although contaminants have been identified in many on-base sites, ***on-base residents or visitors, and the neighboring community are not exposed to contaminants from any of these sites at levels that could cause adverse health effects*** (Table 1). ATSDR did identify some potential past exposures that cannot be completely evaluated due to insufficient data. These include:

1. *Past exposure to air emissions.* Past air emission sources include an incinerator which apparently operated between 1942 and 1951. Little information is available about the actual time period it operated, how it was used, or the locations of past on-base family housing areas. As a result it is not possible to evaluate whether people could have been affected by past releases.

2. *Past exposure to drinking water.* Jones Pond was the source of drinking water at CAX from the 1940s to 2002. The Navy filtered, treated, and sampled the water in accordance with federal Safe Drinking Water Act requirements. However, samples were not analyzed for explosive compounds (also known as nitroaromatics) because they are not part of the regulatory requirements. Traces of nitroaromatics were detected, below levels of health concern, in 1999 and 2000 surface water and sediment samples from Jones Pond and its tributaries. The nitroaromatics could have been introduced from the nearby Penniman era disposal sites. Although sampling data obtained since 1999 indicate the nitroaromatics were not a health concern at that time, no information is available to estimate whether the concentrations were higher, or lower, in the past. Therefore, ATSDR cannot draw conclusions about past exposure to drinking water from Jones Pond. Currently no one is drinking water from Jones Pond. The Navy distributes drinking water from the Newport News Waterworks; this water is treated and sampled regularly to ensure it is safe to drink.

3. *Past exposure to fish in Penniman Lake and Youth Pond.* Before 2000, people were permitted to eat fish from all four on-base ponds and lakes. In 2000, polychlorinated biphenyls (PCBs) were identified in sediment samples collected from Penniman Lake and Youth Pond at levels that

could lead to accumulation of PCBs in some types of fish. After that sampling event, the Navy instituted a policy that allowed people to fish from the on-base ponds and lakes, but only eat fish from Cheatham Pond and Jones Pond. PCBs were not detected in Cheatham Pond or Jones Pond; consuming those fish does not pose a health concern. No fish tissue samples were collected from Penniman Lake or Youth Pond. While it is not possible to evaluate if fish from Penniman Lake or Youth Pond contained elevated concentrations of PCBs, past and current consumption of fish from Cheatham Pond or Jones Pond is not expected to cause health problems.

ATSDR identified ***two areas with physical hazards and recommends the Navy take prompt measures to prevent people from coming into contact with these possible safety hazards:***

1. *Buried medical waste.* In the past, some buried medical waste within the fenced-in part of CAX washed into an adjacent pond and then into Youth Pond, which is a destination for Navy families and visitors. A 1998 removal action significantly reduced the potential for waste transport, but not all of the medical waste has been removed. It is possible that some of the remaining waste could be transported into Youth Pond and encountered by recreational users. ATSDR recommends that the Navy complete the remedial actions necessary to prevent additional waste transport from the burial site.

2. *Damaged fence near the rental cabins.* Some of the rental cabins are located near a short cliff overlooking the York River and sites where materials from the Penniman era were buried. A fence that protects visitors from the cliff was damaged in 2003. The two cabins closest to the cliff have not been used since, but other cabins approximately 100 yards away are still used. ATSDR considers this to be a safety hazard because children may try to slip under the fence. The Navy indicated it plans to fix the fence. ATSDR recommends that the fence be repaired as soon as possible or that other measures be taken promptly to reduce this hazard.

During the evaluation, ATSDR also identified ***two items related to future activities:***

1. *Soil and safety concerns.* Some of the disposal sites contain buried materials or soil contaminants. On-base residents and visitors are not currently and were not in the past exposed to contaminants at levels that could cause health concerns from these sites. These areas are in remote locations or behind locked fences. Under current land use, people only have incidental contact with the soil contaminants and little contact with the buried materials. ATSDR expects that if modifications to the land use are proposed, EPA and the Virginia Department of Environmental Quality (VDEQ) approved actions will prevent any exposures that could cause health concerns.

2. *Future discoveries.* CAX is still being actively investigated. Additional environmental sampling is planned for many disposal sites. EPA continues to look for additional information about ordnance manufacturing and disposal processes on portions of CAX where Penniman operations are believed to have occurred. It is possible that new information about past disposal sites could be identified in the future. If new data become available or land use changes are proposed, and if requested, ATSDR will review the new information, if it is likely to modify this health evaluation.

Background

Site Description and Operational History

Naval Weapons Station (NWS) Yorktown, Cheatham Annex (CAX), is located outside Williamsburg in York County, Virginia. The site is adjacent to the York River between Kings Creek and Queens Creek (Figure 1). CAX is approximately 15 miles upstream from the Chesapeake Bay and 35 miles from Norfolk, Virginia. The facility was established in 1943 as Cheatham Annex Supply Center, a satellite unit of the Naval Supply Depot in Norfolk. During World War II, CAX was used for bulk storage and as an assembly location for products to be shipped overseas. Since the war, the primary mission of CAX has been to receive, store, pack, and ship materials to federal facilities on the East Coast and distribution centers in Europe (CH2M Hill, Baker, and CDM 2001; U.S. Environmental Protection Agency [EPA] 2000a; EPA 2003c).

At CAX, the Navy maintains and distributes mechanical, electronic, and navigational equipment for ships, as well as personal effects. The annex also provides warehouse and distribution services for other military storage programs and tenant organizations. CAX was an annex of the Fleet and Industrial Supply Center Norfolk from the 1940s until 1998, when it was transferred to NWS Yorktown. The transfer did not affect its mission (CH2M Hill, Baker, and CDM 2001; EPA 2000a; EPA 2003c).

CAX originally occupied approximately 3,400 acres, but several parcels have been transferred to other agencies, leaving CAX a little less than half of its original size (Figure 2). In 1976, approximately 540 acres immediately south of Queens Creek (and east of the Queen Lake housing area) were transferred to York County. This parcel is currently a York County park called New Quarter Park, and includes a floating pier on Queens Creek (Noel 2003). In 1979, approximately 790 acres were transferred to the U. S. Department of Interior, National Park Service (NPS). This transfer included a large parcel north of Sanda Avenue and east of the land transferred to York County. The boundary between CAX and the property transferred to the NPS parallels Sanda Avenue as far as A Street, then runs along the eastern edge of Cheatham Pond. NPS has made this area part of the Colonial National Historical Park. The NPS also holds a right-of-way easement through the center of the Navy's property, now traversed by the Colonial National Historical Parkway, as well as a parcel at the mouth of Kings Creek that is approximately 1 mile long and 1/3 mile wide. In 1981, the Navy sold to the Virginia Department of Emergency Services approximately 460 acres that had previously been used for fuel storage, referred to as the Fuel Farm or the Virginia Fuel Farm. The Fuel Farm shares borders with NPS property and NWS Yorktown (EPA 2000a; EPA 2003c; Weston 1999a; Naval Supply Corps 2002).

CAX comprises two separate sections on either side of the Colonial National Historical Parkway; totaling approximately 1,578 acres (Figures 1 and 2). The larger parcel is north of the Parkway and east of Cheatham Pond, west of Kings Creek, and south of the York River. Most base activities take place on this parcel. The smaller parcel is south of the parkway, west of Penniman Road and the Virginia Fuel Farm. This smaller parcel includes Jones Pond, which served as CAX's water supply until 2002 and is open to fishing and boating. Much of the remainder of this parcel has been designated a watershed protection area (CHM2 Hill, Baker, and CDM 2001; Newport News Waterworks 2002). No decision has been made about whether there might be future development of this parcel now that the pond is no longer used to supply drinking water to CAX. Currently, the area is used for recreation (Public Works Center [PWC] Regional Environmental Group 2003d).

There are 18 warehouses at CAX, all were built by 1943 and are located north of Sanda Road (Naval Supply Corps 2002; GlobalSecurity.org 2002). More than 50% of the land that is currently part of CAX is undeveloped. This includes almost 200 acres of lakes and marsh. In 1987, the Navy designated CAX the Hampton Roads Navy Recreational Complex to provide recreational opportunities to military and civilian personnel throughout the region. The Navy created outdoor recreational facilities in designated areas within CAX, including cabins, campsites, recreational vehicle sites, ball fields, a golf course, and a pool (NWS Yorktown n.d.a., n.d.b.). There are four on-base lakes and ponds, Cheatham Pond, Jones Pond, Penniman Lake, and Youth Pond, used for boating and fishing. Navy personnel indicated that posted signs state that swimming in these four water bodies is not allowed (Hill 2004). Hunting is allowed within selected areas at CAX and the York River is used for commercial and recreational fishing and crabbing (CH2M Hill, Baker, and CDM 2001).

Site History Before World War II

Much of the area that later became CAX supported the war effort during World War I and later used for farming. In 1916, E.I. Dupont de Nemours Company (DuPont) constructed a dynamite (2,4,6-trinitrotoluene [TNT]) manufacturing plant at the site. Even though TNT production lines were constructed, historical records indicate that TNT production never began. In 1917, the U.S. government contracted with DuPont to construct a shell loading plant, to load explosives into large-caliber shells, near the idle TNT plant. The plant and the city that grew up around the plant were both named after Russell Penniman, the inventor of ammonia dynamite. At its largest, the city was home to over 15,000 people (Naval Fleet Industrial Supply Center 2001). The Penniman Shell Loading Plant had the capacity to load more than 54,000 shells every day. It was one of the top five ordnance-producing plants in the world. The U.S. government reportedly paid for the equipment and supplies needed for shell loading, as well as for removing finished shells and casings. The Shell Loading Plant also included magazine areas, along with a booster plant that was located between Cheatham Pond and Queens Creek (EPA 2003a; Goodwin 1994).

After the war ended in October 1918, DuPont was instructed to decommission remaining shells (i.e., take them out of service), but the manner in which that was done is unknown. Decommissioning was reportedly completed in February 1919. DuPont also dismantled the plant and salvaged certain materials (Weston 1999a; Goodwin 1994). Beginning in late 1918 or early 1919, the U.S. government operated the Penniman General Ordnance Depot at the site, which operated side-by-side with DuPont workers. The primary activities of the Penniman General Ordnance Depot were the preparation of manufactured ordnance and explosives for long-term storage and shipment to other ordnance depots in the United States (Weston 1999a). Whether ordnance and explosives were disposed of in any other manner is unknown.

Little specific information is available about the disposal of shells and explosive materials that remained at the Penniman site after WWI. Records indicate that approximately 5 million pounds of ammonium nitrate were to be shipped to a company in North Carolina, and almost 50,000 155-milimeter shells were shipped to a site in Suffolk, Virginia, now known as Nansemond Ordnance Depot (Weston 1999a). Records associated with the former Nansemond Ordnance Depot also indicated that some shells from the Penniman plant were shipped there after the war, but the quantity of shells received at Nansemond is thought to be substantially smaller than what would have been present at the Penniman plant at the end of the war. In addition, shells of four other sizes were produced at the plant and were presumably present there when the war ended. According to EPA, other ammunition expected to have been present at that time has not been accounted for (EPA 2003a).

Records indicate that fewer than 100 people lived in the city of Penniman by mid-1919 (Naval Fleet Industrial Supply Center 2001). By 1926, the Penniman General Ordnance Depot had closed, and DuPont had dismantled the former TNT plant and shell loading plant structures. That same year, all of the property associated with Penniman activities was sold to a private owner for farmland. In 1942, the U.S. Navy condemned more than 3,000 acres along the York River to establish CAX. Much of the condemned property is believed to have been part of the Penniman Shell Loading Plant and its successors (Weston 1999a). By 1943, the government had constructed 10 storehouses, one cold-storage building, and two piers at Cheatham Annex. Some of the warehouses were built on the foundations of Penniman buildings. Additional storage and support facilities were added over time. Maps of the specific locations where different Penniman activities occurred suggest that approximately half of the land CAX transferred to the NPS in 1979 had been part of the Penniman complex.

Remedial and Regulatory History

In 2000, Cheatham Annex was added to the National Priorities List (NPL), pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERLCA), but investigations and remediation at CAX began in the 1980s. A Navy program to assess environmental contamination associated with its installations, known as the Installation Restoration Program (IRP), was created in the early 1980s. An Initial Assessment Study (IAS) completed in 1984 reviewed available information about 12 CAX sites potentially affected by contamination from past waste-handling practices. This assessment was followed by a series of investigations and remedial measures (Baker 1997; CH2M Hill and Baker 2000b; CH2M Hill 2002; Dames & Moore 1986; Dames & Moore 1988). The bulk of the work conducted at IRP sites since 1997 has addressed contamination at Sites 1, 4, and 11. In 1998, the Navy identified five additional sites potentially affected by contamination and designated them areas of concern (AOCs) 1–5. All of the IRP Sites and AOCs are described in greater detail in Table 2. Major work conducted at the CAX IRP sites and AOCs is summarized below.

- At Site 1 - Landfill, investigations conducted in 1998, 1999, and 2000 supported a remedial investigation (RI). In 1998 and 1999, the Navy noted shoreline erosion of the bank of the York River near the site, including a partially exposed 60-foot section of the Site 1 landfill and surface debris in the vicinity. Debris was removed from the beach, and the eroding area was temporarily stabilized. In summer 2003, the Navy removed approximately 20,000 cubic yards of contaminated soil, landfill material, and debris. A final RI for Site 1 is in progress. The Navy will also evaluate how to investigate and address potential sediment and groundwater contamination, including contaminants affecting the adjacent wetland area (Baker 2003; Harlow 2003; Bridges 2003).

- At Site 11 - Bone Yard, tanks and drums of gasoline and oil, scrap metal, and other debris had been dumped and/or buried prior to 1978. A removal action was conducted in 1987. A second removal action in 1997, transported approximately 60 tons of materials, including drums, tanks, scrap, and debris, off site (CH2M Hill and Baker 2000b). The Navy continues to investigate this site 11.

- At Site 4 - Medical Supplies Disposal Area, the Navy removed surface debris and sharp metal and plastic items in 1998. Some of these items were reported to have periodically washed into an unnamed pond within the fenced-in industrial area and then into Youth Pond in prior years. Some waste material still remains. The Navy has investigated the extent of the remaining buried waste and is evaluating remedial options.

- Surface water and sediment samples were collected in 2000 from the four named water bodies at CAX that are used for recreation. Sampling was in support of a planned ecological risk assessment (ERA) (CH2M Hill and Baker 2000a). Rather than preparing an ERA for all of CAX, the Navy plans to focus ERA data evaluations on particular IRP sites. An ERA for Sites 4, 9, and 11 was drafted in late 2003; previously, the Navy had investigated the extent of contamination at Site 9 in 1999 and Site 4 in 2001 (Harlow 2003, Bridges 2003).

- In September 2003, the Navy, with EPA and VDEQ concurrence, assigned No Further Response Action Planned (NFRAP) status to Sites 2, 3, 5, 6, 8, and 10 (CH2M Hill and Baker 2003b).

- Five documents were originally expected to be finished around the end of 2003: the ERA, RIs for Sites 1 and 11, a report documenting the findings of a limited field investigation at Site 12, and a study presenting information about background levels of contaminants at CAX (CH2M Hill and Baker 2001b). However, final drafts have not yet been issued (McConaughy 2004).

Contamination at CAX results not only from Navy activities, but also from the operations of the former Penniman Shell Loading Plant. EPA analyzed historical aerial photographs to identify areas currently or formerly part of CAX potentially worthy of further investigation and completed a Site Investigation (SI) of those areas (EPA 1998; EPA 2003a; Weston 1999a). The SI included soil, sediment, and surface water sampling at the locations of 10 potential sources of contamination. EPA samples from all 10 locations contained elevated levels of contaminants, most commonly arsenic and lead. Chromium, manganese, and TNT were also detected in some samples (Weston 1999b).

In December 2000, EPA added CAX to the NPL, on the basis of EPA's analysis of eight sources of contamination at CAX: IRP Sites 1, 10, and 11, and five sources of contamination associated with the Penniman Shell Loading Plant (known collectively since then as the Penniman AOC). EPA noted that contamination from these sites was not fully contained and might migrate to adjacent surface water bodies, which serve as recreational fisheries. Insufficient data were available at that time to assess the impact of contaminant migration into those surface water bodies (EPA 2000c).

The Penniman AOC is entirely on Navy property and does not include IRP Site 7, Site 13, or AOC 1 (each of which potentially includes waste relating to the Penniman plant). However, IRP Site 7, Site 13, and AOC 1 are affected by contamination from the Penniman era.

The Penniman Shell Loading Plant operated before CAX was established and spanned most or all of the area that became part of CAX. Current investigations suggest that environmental contamination by Penniman activities generally affects just the past production and disposal areas. This PHA discusses two Installation Restoration Program (IRP) sites (Sites 7 and 13) and two areas of concern (AOCs) (AOC 1 and the Penniman AOC). All of these sites are potentially affected by the Penniman plant.

Site 7 was described in the IAS as a disposal area near the York River that received waste from the City of Penniman and the former DuPont facility, including ammunition waste. Initially, its location could not be identified from the map in the IAS. When an inspection and sampling were conducted in 1999 at what was thought to be the Site 7, the site investigated turned out *not* to be the location described in the IAS as affected by waste disposal during the Penniman era.

Site 13 was discovered in 2000 and appears to be the area described in the IAS, it has been identified at the Penniman Disposal Area. In the future, waste and contamination present there will be addressed along with Site 7. Sites 7 and 13 are very close to each other, within approximately 300 feet of the York River.

AOC 1 is a landfill near Jones Pond that is thought to have received some waste during the Penniman era.

The **Penniman AOC** is distinct from AOC 1, Site 7, and Site 13. It comprises five locations identified by EPA in 1999. Each of the five locations was affected by contamination resulting from activities conducted while the Penniman Plant operated. Three of the locations in the Penniman AOC are along the southern shore of Penniman Lake; the other two are also within the northeastern part of CAX.

ATSDR Involvement

In November 2000, the Agency for Toxic Substances and Disease Registry (ATSDR) conducted an initial site visit to gather information necessary for initiating the public health assessment process at CAX. During the site visit, ATSDR toured the site and met with representatives of CAX, the Atlantic Division of the Naval Facilities Engineering Command, and the Navy

Environmental Health Center. We also identified representatives of other interested agencies, including the Department of Interior and Virginia Department of Emergency Management. ATSDR identified past, current and future exposure pathways at CAX, but determined that none of these pathways posed an imminent public health threat (ATSDR 2000a; ATSDR 2001).

Demographics

The U.S. Census Bureau identified more than 56,000 people living in York County in 2000, including 3,500 were military personnel. Williamsburg had approximately 12,000 residents in 2000 (Bureau of the Census 2001; York County Planning Division 2003). On-base housing includes approximately 13 family housing units, 16 apartment buildings, and bachelor quarters (Norfolk Department of Planning and Community Development n.d., Hill 2004, Weston 1999a). As of 1999, approximately 1,840 people worked at CAX (Weston 1999a). Aside from the on-base residences, the nearest homes to CAX are located along Route 641, immediately east of the southwestern portion of CAX (CH2M Hill, Baker, and CDM 2001).

In 2000 an estimated 2,416 persons lived within 1 mile of CAX, including 172 children less than 6 years of age (Figure 3). There are no schools within 1 mile of CAX, but there is a playground near the on-site family housing units (CH2M Hill, Baker, and CDM 2001; Norfolk Area Naval Housing Office n.d.).

Land Use and Natural Resources

CAX is located along the York River. The York River watershed is larger than 2,500 square miles and is affected by numerous point and non-point sources of pollution (Virginia Institute of Marine Sciences [VIMS] 1994). Boating occurs throughout the river, and there is also a popular beach north (upstream) of CAX. The York River is a popular site for both recreational and commercial fishing and crabbing. Besides crabs, other shellfish found off-shore of CAX include oysters and hard and soft clams (Baker 1991; Baker and Weston 1994).

The main (northeastern) part of CAX contains buildings, recreation areas, and Cheatham Pond, Penniman Lake, and Youth Pond. There is an unnamed pond immediately upgradient of Youth Pond, but the upstream pond is within the fenced warehouse area, while Youth Pond is outside of it. The CAX warehouses are located north of Sanda Avenue, as are some small buildings used for mission support activities. Administrative and support structures line the south side of Sanda Avenue, before it reaches two piers extending into the York River. Near the piers are officer housing and a golf course (Goodwin 1994). Bachelors' quarters are located due north of Penniman Lake (Harlow 2003; Bridges 2003). There is a picnic and camping area along the northeastern shore of Penniman Lake. There are also cabins that can be used by Navy families along the edge of Cheatham Pond, on both Navy and NPS property.

The major feature in the southwestern part of CAX is Jones Pond. The pond is approximately 62 acres in size and is spring-fed (PWC Regional Environmental Group 2003b). It is dammed at the Colonial National Historical Parkway; beyond the dam, water flows to Queens Creek. There is also a camping area near Jones Pond, as well as a boat ramp on the eastern side of the pond (PWC Regional Environmental Group 2003d; Tucker 2003).

Navy personnel and their families fish in Cheatham Pond, Jones Pond, Penniman Lake, and Youth Pond. Since 2000, fishing in the latter two water bodies has been designated for "catch and release" only. Residents and visitors are still permitted to eat fish they catch in Cheatham Pond and Jones Pond (Harlow 2003; Bridge 2003). Boating and fishing occurs at most or all of the four water bodies, but swimming is currently and was in the past prohibited. Signs to this effect are posted at some or all of the ponds or lakes (Hill 2004).

Hydrogeology and Groundwater Use

Topographically, CAX is characterized by gently rolling terrain, with ravines and stream valleys trending mainly northeast, in the direction of the York River, which is at sea level. In the western part of Cheatham Annex (i.e., near Jones Pond), hills reach a height of 90 feet above mean sea level. Steep 40- to 60-foot ravines run along the major creeks at CAX (Baker and Weston 1994). Groundwater tends to flow toward surface water features, such as Kings Creek, Queens Creek, the York River, small tributaries, and springs. It also may flow to wetlands areas, such as those between Jones Pond and Queens Creek (Nelms 2002, 2003).

Groundwater is encountered at depths as shallow as 10 to 20 feet below ground surface (bgs). Regional shallow groundwater units, described as the York County shallow aquifer system, are comprised of three layers. From shallowest to deepest, they are the Columbia aquifer, which is unconfined, the Cornwallis Cave confining unit, and the Cornwallis Cave aquifer. The Cornwallis Cave confining unit is missing in some areas, particularly near the York River. Even in areas where it is present, it serves only as a "leaky" confining unit because it does not effectively provide a barrier between groundwater in the Columbia aquifer and groundwater in Cornwallis Cave aquifer (USGS 1997; USGS 2001; Nelms 2003). Most groundwater samples have been collected from the shallow aquifer system. The only IRP sites or AOCs where there has been groundwater sampling are Sites 1 (at 3 to 11 feet bgs), 10 (at 23 to 25 feet bgs), and 11 (15 to 21 feet bgs), as well as AOC 2 (20 to 38 feet bgs). Beneath the Cornwallis Cave aquifer is the Yorktown confining unit, comprised of clays and silts, followed by the Yorktown-Eastover aquifer. The Yorktown confining unit is also absent in some areas, including locations near the York River (Baker and Weston 1994; Baker 1997; CH2M Hill and Baker 2001a).

Between approximately 1943 and October 2002, drinking water used at CAX came from Jones Pond. Before being distributed, pond water was filtered and chlorinated at a treatment plant located near the intake, on the eastern side of the pond, approximately 2,000 feet south of Colonial National Historic Parkway (PWC Regional Environmental Group 2003a; Virginia Department of Health, Office of Drinking Water 2003). Water filtration has been documented as having occurred at least as early as 1961 (PWC Regional Environmental Group 2003b). Water was treated and sampled in accordance with the provisions of the Safe Drinking Water Act (SDWA). The treatment plant was upgraded in approximately 1991. After the Fuel Farm was transferred to the Virginia Department of Emergency Services in 1981, CAX continued to provide water to one building there (PWC Regional Environmental Group 2003a).

Newport News Waterworks, a department of the City of Newport News, distributes water to Newport News, Hampton, and Poquoson, as well as parts of York County and James City

County. By mid-2002, the Newport News water distribution system had been extended sufficiently far into the Williamsburg area that it could provide water to CAX. In 2002, the source of water for CAX from switched from Jones Pond to water distributed by the Newport News Waterworks (PWC Regional Environmental Group 2003a). The Newport News Waterworks draws water from sources that are more than 4 miles from CAX and treats and samples the water before distributing it, in accordance with SDWA requirements (Naval Public Works Center 2001).

Residences near CAX may currently or may have originally used wells for drinking water, given that a public water supply was not available on some streets until the last several years. In the past, there was no comprehensive requirement for individuals or institutions to notify state, county, or city agencies before or after drilling private wells. ATSDR contacted several state and local agencies to inquire about available information on any residential and commercial private wells that might be (or have been) present near CAX, outside of its boundaries. It appears that a small number of drinking water wells could exist near the base, although specific information about the potential wells was generally not identified (VDEQ 2003b; Weston 1999b; Jordan 2004).

Scientists who have studied hydrogeologic conditions in the area indicate that the one known well would not be affected by any groundwater contamination coming from CAX (Tucker 2003; Nelms 2003). The available information indicates that off-site wells would not be affected by CAX activities because there is no known groundwater contamination associated with CAX that extends beyond its boundaries.

Quality Assurance and Quality Control

In preparing this PHA, ATSDR reviewed and evaluated information provided in the referenced documents. Documents prepared for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program must meet standards for quality assurance and control measures for chain-of-custody, laboratory procedures, and data reporting. The environmental data presented in this PHA come from site characterization, remedial investigation, and groundwater monitoring reports prepared by CAX under CERCLA. Based on our evaluation, ATSDR determined that, overall, the quality of environmental data available for CAX is adequate for making public health decisions.

Evaluation of Environmental Contamination and Potential Exposure Situations

Introduction

During a public health evaluation, ATSDR evaluates whether people are coming in contact with environmental contaminants released at the base and, if so, whether or not the exposure could affect the health of on-base residents or visitors, or the neighboring community. Figure 4 provides an overview of ATSDR's exposure evaluation process, which is described in more detail below. Appendix C defines some of the technical terms used in this PHA.

What is meant by exposure?

ATSDR's PHAs are driven by evaluation of the potential for human exposure, or contact with environmental contaminants. Chemical contaminants released into the environment have the potential to cause adverse health effects. However, *a release does not always result in human exposure*. People can only be exposed to a contaminant if they come in contact with it—if they breathe, eat, drink, or come into skin contact with a substance containing the contaminant.

How does ATSDR evaluate whether exposures are harmful?

ATSDR evaluates the conditions at each on-base site where contaminants have been identified in the environment to determine if people could have been, are, or could be exposed (i.e., past, current, or future exposures) to contaminants at levels that could cause adverse health effects. If exposure is possible, ATSDR further evaluates the site by comparing the concentration of the contaminants measured in the environment to health-based comparison values (CVs).

CVs are developed by ATSDR from scientific literature related to potential health effects from exposure to a contaminant. A significant amount of toxicological and epidemiological information is available for most of the contaminants commonly found at military bases. As a result, a specific CV has been developed for the majority of those contaminants. CVs are derived for each of the different media and reflect an estimated contaminant concentration that is *not expected* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., an amount of water or soil consumed or an amount of air breathed) and body weight.

CVs are not thresholds for adverse health effects. ATSDR CVs establish contaminant concentrations that are many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above CVs, ATSDR further analyzes the exposure variables to evaluate if adverse health effects are, or are not, expected to occur. The primary exposure variables include the duration and frequency of exposure, the toxicology of the contaminant, and results of epidemiology studies.

> ***If someone is exposed, will they get sick?***
>
> *Exposure does not always result in harmful health effects.* The type and severity of health effects a person can experience because of contact with a contaminant depend on the exposure concentration (how much), the frequency and/or duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the toxicity of the contaminant. Once an exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the possible health effects that may occur.

Some of the CVs used by ATSDR include ATSDR's environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs) and EPA's maximum contaminant levels (MCLs). MCLs are enforceable drinking water regulations developed to protect public health. CREGs, EMEGs, and RMEGs are non-enforceable, health-based CVs developed by ATSDR for screening environmental contamination for further evaluation. Appendix D provides an overview of the CVs that ATSDR used in evaluating site environmental data.

In almost any situation, there is considerable uncertainty about the true level of exposure to environmental contamination. To account for this uncertainty and to be protective of public health, ATSDR typically uses reasonable exposure level estimates as the basis for determining whether adverse health effects are possible. These estimated exposure levels are often much higher than the levels that people are really exposed to. If the exposure levels indicate that adverse health effects are possible, ATSDR performs a more detailed review of exposure, also consulting the toxicologic and epidemiologic literature for scientific information about the health effects from exposure to hazardous substances.

What potential exposure situations were evaluated for Cheatham Annex?

ATSDR identified the following five potential exposure situations at and near CAX for in-depth evaluation and discussion:

- *Potential exposure to contaminants in drinking water.*
- *Potential exposure to surface water, sediment, and fish at on-site water bodies.*
- *Potential exposure to contaminants associated with past operations of the Penniman Shell Loading Plant.*
- *Potential exposure to physical hazards at and near CAX IRP sites.*
- *Potential exposure to contaminants at the former Virginia Fuel Farm.*

Table 1 provides a summary of all potential exposure situations evaluated by ATSDR. Information about IRP sites and AOCs at CAX, along with our evaluations of potential exposures, is summarized in Table 2. Even though soil is contaminated in some locations, Navy families and the public are not exposed to soil contaminants at levels that could cause health effects. Sites that have, or had, higher levels of soil contamination are located inside fenced areas or remote areas of the base. As a result, residents and visitors have had only limited contact with the contaminated soil. ATSDR expects that EPA and VDEQ oversight of remedial actions at those sites will eliminate the potential for people to come into contact with soil contaminants at levels of potential concern in the future, if access constraints are modified in such a way as to allow unrestricted access. There is no exposure to contaminated groundwater, as it is not used for on-base drinking water. While some off-base private drinking water wells may exist, those wells are not expected to be affected by contaminant detected in the groundwater at CAX. Exposures to seafood from water bodies that extend beyond the boundaries of CAX (and those in other local communities) are discussed in the "Community Health Concerns" section of this document, as well as in an associated appendix.

ATSDR did not identify any current sources of air emissions at CAX. Limited information indicates an incinerator did operate between 1942 and 1951. However, it is not known if it operated between 1951 and 1990, when it was dismantled, what it burned, or how often it was used. The nearest family housing area that is still in use was over 1 mile away. Locations of additional family housing areas that may have existed in the past are not known. Given these data gaps and the fact that there are no records on incinerator emissions, ATSDR cannot evaluate whether people could have been affected by possible past releases. Emissions usually disperse quickly, and any exposures would likely have been intermittent and reduced with distance from the source.

Potential Exposure to Contaminants in Drinking Water

Jones Pond was the source of on-base drinking water from the 1940s through 2002. Currently, CAX receives its drinking water from the City of Newport News. This section reviews information about past waste disposal practices near Jones Pond because contaminants released at those disposal sites may have affected the water quality of Jones Pond. This section does not discuss groundwater contamination at CAX because the Navy did not use groundwater for drinking water and the existing off-base private drinking water wells are not expected be affected by groundwater contamination from CAX.

Background

The Cheatham Annex Water Supply

The Cheatham Annex water supply system was established in the early 1940s. Water was drawn from Jones Pond. Historical documents indicate that CAX filtered water it distributed at least as early as 1961 (PWC Regional Environmental Group 2003b). There is little or no other information available about filtration, treatment, and sampling conducted at CAX prior to the 1960s, when safe drinking water requirements went into effect. The original CAX treatment plant was replaced by a new water treatment plant around 1990 (PWC Regional Environmental Group 2003b). CAX complied with all SDWA and VDH requirements, including sampling treated water prior to distribution.

What were the requirements for treating and testing drinking water in the past?

Water supply systems are required to treat and sample water under the Safe Drinking Water Act (SDWA), passed in 1974 and amended in 1986 and 1996. The U.S. Public Health Service had published recommended drinking water standards beginning in 1914, when the standards addressed only bacteriological contaminants. The standards were revised and expanded in 1925, 1942, and 1962, at which time they addressed 28 potential types of contamination. The 1962 standards, adopted in some form by all of the states, were later superceded by SDWA requirements (EPA 1999c). The CAX water supply complied with all SDWA and Virginia Department of Health requirements.

ATSDR reviewed available records about sampling conducted at the CAX water treatment plant. However no information was available for sampling conducted prior to the 1990s. According to EPA records and VDH, levels of chemical contaminants measured in post-treatment samples from the CAX water treatment plant have consistently been below regulatory limits for the past approximately 10 years (EPA n.d.a.; D. Tucker, 2003). As of 2002, samples of water treated by the CAX treatment plant (i.e., post-treatment samples) were analyzed for metals annually, for volatile organic compounds (VOCs) every three years, for radiological contaminants every four years, and for cyanide every nine years. In prior years, through the 1990s, samples were also analyzed periodically for synthetic organic contaminants (SOCs). These SOCs included pesticides, polychlorinated biphenyls (PCBs), dioxin, and a few volatile and semi-volatile organic compounds. During that time SOCs were only detected at low concentrations (Tucker 2003; EPA 2002).

In 2002, CAX started using the Newport News water supply as its source of drinking water (PWC Regional Environmental Group 2003a). The Navy is still responsible for distributing the water throughout Cheatham Annex and performing some monitoring, such as sampling for disinfection byproducts and bacteriological contamination (Tucker 2003).

Studies of Contaminants Potentially Affecting Jones Pond

The Navy identified two historical disposal areas (Site 12 and AOC 1) in the southwestern portion of CAX that could be sources of contamination affecting Jones Pond. While the Virginia Fuel Farm is also located west of AOC 1 and Site 12 (across Route 641), EPA reports that groundwater contamination from the Fuel Farm does not extend beyond the boundaries of the Fuel Farm (EPA 1999a, b). The IAS indicated that Site 12, within approximately 300 feet of a tributary to Jones Pond, was used at one time for surface disposal of scrap metal, including automobile parts and iron pipe. The metal debris are no longer present and may have been moved to an off-site disposal area or to AOC 1. AOC 1 is approximately 1,000 feet from Jones Pond and was identified in 1998 following site visits by the Navy, EPA, and VDEQ. Aerial photographs from 1942 and 1963 indicate activity in the area (CH2M Hill 2000). Some of this waste dates to the Penniman era (Weston 1999a). However, no documentation was identified that described historical disposal practices for this site. The partially buried debris includes drums, metal objects, wood, gas cylinders, and construction debris. AOC 1 is located within two neighboring ravines that ultimately empty into Jones Pond.

ATSDR identified three sampling events for Jones Pond and its tributaries, two in 1999 and one in 2000 (CH2M Hill and Baker 2000a; Weston 1999b; CH2M Hill and Baker 2003a). Low concentrations of nitroaromatics (specifically TNT and 4-amino-2,6-dinitrotoluene) were intermittently detected in the surface water and sediment at concentrations below CVs. Two other organic compounds and three metals were also intermittently detected in the surface water samples. Details about these sampling events and their results are presented below.

> ***Nitroaromatics*** are organic chemicals at least one nitro group ($-NO_2$) bonded to one or more carbons in a benzene ring. They are present in some pesticides, herbicides, industrial chemicals and explosives. The presence of TNT with the other nitroaromatics suggests they may be the result of previous Penniman activities.

- January 1999 EPA Site Investigation of the Penniman Shell Loading Plant. As part of its effort to assess potential effects of the Penniman Shell Loading Plant, EPA collected surface water and sediment samples from Jones Pond and the tributary to Jones Pond that receives runoff from AOC 1. One surface water sample was collected from the pond, along with one sediment sample. Results from one sediment sample from the tributary were also presented. The surface water sample was analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides, PCBs, and metals. The sediment samples were analyzed for the same classes of chemicals, plus nitroaromatics (Weston 1999b).

- November 1999 Navy Investigation of AOC 1. In November 1999, the Navy investigated AOC 1 and collected soil, surface water, and sediment samples. Samples from both the southern and northern tributary were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and nitroaromatics. There were a total of three surface water samples and four shallow sediment samples (CH2M Hill and Baker 2003a).

- March 2000 Pond Study. The Pond Study included results of surface water and sediment sampling of the four on-base water bodies. Only one sample was from Jones Pond. It was close to the shoreline in one of the "fingers" feeding into the east side of the pond, west and slightly north of AOC 1. The sampling location was approximately 800 feet upstream from the Navy intake and approximately 450 feet south and slightly west of a location that had been sampled in January 1999 by EPA. Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and nitroaromatics (CH2M Hill and Baker 2000a).

The results of these three sampling events (Table 3) represent only a snapshot (in space and time) of the water and sediment conditions at and near Jones Pond, but provide some insights regarding what might be in or carried to Jones Pond and supplements the sampling data collected under the SDWA.

Nitroaromatics
Nitroaromatics were not measured as a part of the sampling for the SDWA. Reported levels of nitroaromatics in Jones Pond and its tributaries (surface water and sediment) obtained during the environmental investigations were generally low. Almost all of the nitroaromatics were detected at concentrations below ATSDR CVs. Cyclotrimethylenetrinitramine (RDX) was detected in one surface water sample; TNT and 4-amino-2,6-dinitrotoluene were detected in one and two sediment samples, respectively. These sampling results are summarized in the following tables. The actual presence or representativeness of nitroaromatics in the samples is uncertain in some cases. Based on sampling documentation, some of the reported contamination might have been introduced during sampling procedures or laboratory analysis. Therefore, ATSDR cannot draw firm conclusions about exposures or health implications based on these samples alone.

Other organics (VOCs, SVOCs, pesticides, and PCBs)
Only two non-nitroaromatic organic compounds were measured in surface water samples at concentrations exceeding CVs. Bis(2-ethylhexyl)phthalate was detected at levels up to 98 ppb in a tributary sample exceeding its CV (4.8 ppb), but was detected at concentrations below the CV in surface water from Jones Pond (CH2M Hill and Baker 2003a). All concentrations of bis(2-ethylhexyl)phthalate in sediment samples were below CVs.

Surface water sampling results for nitroaromatics from Jones Pond and tributaries

Sample Location	Sampling Event	Number of Samples	Concentration of Nitroaromatics Detected in Surface Water (ppb)	CVs of Nitroaromatics in Drinking Water (ppb)
Jones Pond	Pond Study	1	RDX, 0.11B	0.3
Tributaries	Penniman SI	3	None detected	

B: Indicates that the sample was also detected in either a field or laboratory blank. RDX detected in the sample was slightly lower than the concentration measured in the blanks (0.17 ppb and 0.21 ppb RDX).
CV: comparison value
ppb: parts per billion

Sediment sampling results for nitroaromatics from Jones Pond and tributaries

Sample Location	Sampling Event	Number of Samples	Concentration of Nitroaromatics Detected in Sediment (ppm)	CVs of Nitroaromatics in Soil (ppm)
Jones Pond	Penniman SI	1	None detected	
Jones Pond	Pond Study	1	4-amino-2,6,-dinitrotoluene, 0.095	16
Tributaries	Penniman SI	1	TNT, 0.25 4-amino-2,6-dinitrotoluene, 11B	20 16
Tributaries	SI of AOC 1	4	None detected	

For comparison, detected levels of nitroaromatics in sediment samples from the other three on-site ponds were similar. TNT and its breakdown products were detected at levels below 0.1 ppm in samples collected from Youth Pond and Cheatham Pond and at levels ranging from approximately 0.1 to 2 ppm in Penniman Lake (CH2M Hill and Baker 2000a).
B: Indicates that the sample was also detected in either a field or laboratory blank.
CV: comparison value
ppm: parts per million

During EPA's 1999 investigation, heptachlor was measured in a Jones Pond surface water samples at a maximum concentration (0.012 ppb) slightly exceeding its CV (0.008 ppb). In a duplicate sample collected from the same location, a concentration of 0.008 ppb was measured. However, the validity of the detection is not known due to possible blank contamination (Weston 1999b). Heptachlor was not measured in the only other surface water sample from Jones Pond, collected as part of the Pond Study.

Metals

Metals were not detected in the surface water of the tributaries or Jones Pond at concentrations above ATSDR's CV. Arsenic was detected in the sediment of Jones Pond at maximum concentration of 5.6 ppm exceeding the ATSDR CV for soil (0.5 ppm).

Discussion

A trace concentration of one nitroaromatic compound (RDX) was measured in the only available surface water sample from Jones Pond, at a concentration below the CV. Even regular exposure to the detected concentration would not have caused adverse health effects. Furthermore, the RDX detected in the sample may have been accidentally introduced during the sampling process, and may not be the result of RDX in Jones Pond. No nitroaromatics were detected in three surface water samples from the tributary. However, nitroaromatics were measured in some of the sediment samples from Jones Pond and a tributary. The concentrations were generally low and below levels of health concern. The nitroaromatics could have been introduced by Penniman-era waste left at AOC 1, and further investigation at that site is planned.

Before 1999, none of the surface water samples from Jones Pond were analyzed for nitroaromatics; including samples collected at the CAX water treatment plant in accordance with

SDWA requirements. Given that sources of nitroaromatics may date back to the Penniman era, it is possible that the past concentrations could have been higher or lower than those reported in the previous tables. As a result, ATSDR cannot assess whether past exposure to nitroaromatics in drinking water from Jones Pond could have posed a health concern.

Bis(2-ethylhexyl)phthalate was only measured at levels exceeding CVs in samples from a tributary to Jones Pond, not in samples from the pond itself. Heptachlor was detected in one surface water sample from Jones Pond, but may have been introduced into the sample during sampling or analysis. The detected concentration only slightly exceeded the CV. Even regular exposure to drinking water containing the detected concentration would not be expected to cause any adverse health effects. Both bis(2-ethylhexyl)phthalate and heptachlor are SOCs regulated by the SDWA. Post-treatment samples were analyzed periodically at the CAX water treatment plant to ensure that concentrations were below SDWA standards. Since CAX water consistently met SDWA standards, past exposure to bis(2-ethylhexyl)phthalate and heptachlor were below levels known to cause health effects.

In 2002, the Navy stopped treating and distributing the water from Jones Pond and connected to the Newport News municipal water supply system. The Navy continues to operate the on-base drinking water distribution network. There is no current or future exposure to drinking water from Jones Pond. The Newport News municipal water supply system draws on water sources outside of Williamsburg, several miles away and unaffected by CAX or Penniman activities.

Potential Exposure to Contaminants in Surface Water, Sediment, and Fish at On-Site Lakes and Ponds

Background

The four major on-site lakes and ponds within CAX are open for boating and fishing. Until 2000, people were allowed to eat fish they caught from all these water bodies. In 2000, the Navy collected and analyzed surface water and sediment samples from all four water-bodies. Based on those results, the Navy now prohibits the consumption of fish caught in Youth Pond or Penniman Lake. This precautionary measure was based on the elevated levels of PCBs measured in sediment samples from those two water bodies. Surface water and sediment sampling results from Jones Pond and Cheatham Pond indicate that PCB concentrations there are below levels expected to affect fish or fish consumers, therefore fish consumption from these ponds is still permitted. The Navy has collected some surface water and sediment samples, however fish tissue samples have not been collected from any of the lakes or ponds (Harlow 2003; Bridges 2003). Consumption of seafood from water bodies that extend beyond the boundaries of CAX is discussed later in this PHA.

A 1994 fish population study by the U.S. Fish and Wildlife Service for Jones Pond, Cheatham Pond, and Penniman Lake concluded that all three had "reasonably healthy" sportfish populations. All three water bodies contained largemouth bass, bluegill, American eel, and a few types of forage fish. Some of them also contained redear sunfish, pumpkinseed, and black crappie. The Fish and Wildlife Service noted that striped bass and striped bass hybrids had historically been stocked in Cheatham Pond, but were not found during the fish population study (Swihart and Daniel 1999).

Swimming in all three ponds and Penniman Lake has always been prohibited. Signs to this effect are posted (Hill 2004). As a protective measure, ATSDR evaluated exposures to Navy personnel and their families that would occur if people accidentally consumed surface water or sediment from any of the four water bodies while boating in, fishing at, or otherwise using any of the four water bodies.

Various IRP sites, AOCs, and/or areas thought to have been used for shell loading or related activities during the time the Penniman plant operated are located near each of the on-base water bodies. For perspective on potential exposures to recreational users of the lakes and ponds, ATSDR reviewed information about their potential sources of contamination. In order to assess possible exposures, ATSDR reviewed surface water and sediment samples from the Pond Study and other documents provided by the Navy and EPA. The Navy collected surface water and sediment samples from Penniman Lake during its confirmation investigations in 1986 and 1987 and in 1992 as part of preparing a site screening process report for Sites 1, 10 and 11 (Baker 1997; Dames & Moore 1998). These samples were analyzed for selected VOCs, SVOCs, and metals. Samples collected during the Pond Study in 2000 were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and nitroaromatics. EPA sampled surface water and sediment in Jones Pond, Cheatham Pond, and Penniman Lake in 1999 (Weston 1999b). Sediment samples were analyzed for the same compounds as the Navy's 2000 samples. Surface water samples were analyzed for the same parameters, with the exception of nitroaromatics.

Tables 3, 4, 5, and 6, address Jones Pond, Cheatham Pond, Youth Pond, and Penniman Lake, respectively. These tables summarize the potential sources of contamination and the contaminants detected at concentrations exceeding ATSDR CVs for each water body. Findings are summarized below.

- Jones Pond. Two sediment samples and three surface water samples were collected from Jones Pond (Table 3). Metals, a few organics, and a breakdown product of TNT were detected in the samples. Heptachlor, and thallium were detected exceeding CVs in the surface water and arsenic was detected above its CV in the sediment (CH2M Hill and Baker 2000a; Weston 1999b).

- Cheatham Pond. Surface water and sediment samples contained metals and very low levels of a few organics and nitroaromatics (most were below CVs) (Table 4). The contaminants detected at concentrations exceeding CVs were arsenic, iron, lead thallium, and RDX (CH2M Hill and Baker 2000a; Weston 1999b).

- Youth Pond. The two surface water samples contained a few metals and very low levels of two nitroaromatics (below CVs) (Table 5). The two sediment samples contained a few metals, Aroclor 1260 (a PCB congener), a pesticide, and trace levels of two nitroaromatics (CH2M Hill and Baker 2000a).

- Penniman. Surface water samples contained a few organics and metals at concentrations exceeding CVs (Table 6). Nitroaromatics were measured at very low levels, below their

CVs. Sediment samples contained metals, Aroclor 1260, and PAHs at concentrations above CVs. Nitroaromatics were detected in the sediment at low levels, below CVs (Baker 1997; CH2M Hill and Baker 2000a; Dames & Moore 1988; Weston 1999b). According to the Navy, additional sampling indicated that PCBs were measured in sediment samples from the drainage ditch leading to Penniman Lake from the public works buildings, but the concentrations measured have not yet been released (Harlow and Bridges 2003).

Discussion

Surface Water and Sediment

ATSDR evaluated the potential for health effects to result from incidental ingestion of surface water or sediment by Navy personnel and their families during recreational activities at the on-site ponds and lakes. We conservatively assumed people are regularly exposed to the highest measured concentration of each contaminant. In reality, contaminant levels fluctuate and lower levels have been observed during different sampling events. Our evaluation assumed that these exposures occurred every day from June through August and 2 days per week (on weekends) in May and September. These assumptions are believed to overestimate the likely exposures of on-base residents and visitors. As a result they are expected to be protective of anyone frequenting these areas, even those who might swim in these waters, even though swimming is not allowed.

For sediment exposures, ATSDR assumed that the adults inadvertently ingest 100 milligrams of sediment each time they visit on-site lakes and ponds, whereas children ingest 200 milligrams of sediment per day. ATSDR assumed that if anyone disregards the signs indicating that swimming is prohibited, they would incidentally ingest between ½ and ¾ cup of water (0.15 liters) over a 3-hour period every time they visit the water bodies (EPA 1997a). For all scenarios evaluated, the estimated exposure doses were consistently below those shown in the scientific literature to cause adverse health effects. For this reason, adults and children coming into contact with surface water and sediment are not exposed to contaminant levels of potential health concern.

Unfortunately, no data about contaminant concentrations prior to the mid-1980s exist, and higher levels of contaminants may have been present in the past, given that the sources of contamination pre-date the mid-1980s. Because earlier data are not available, ATSDR cannot draw firm conclusions about past exposures to surface water and sediment at the on-site water bodies. However, it is likely that people were not exposed to contaminants in the surface water or sediment of the ponds or lakes long enough or often enough to cause health concerns.

Fish Consumption

Fishing has always been allowed in all four of the major CAX on-base water bodies. In 2000, PCBs were detected in sediment samples from Penniman Lake and Youth Pond. The measured PCB concentrations in the sediment ranged between 1.9 ppm to 6.4 ppm for Aroclor 1260. No other forms of PCBs were measured in the samples. No PCBs were detected in the Penniman Lake sediment samples gathered in 1999. In addition, PCBs were not detected in three 1999 samples collected near former Penniman buildings, along the south-central shore of the lake.

Subsequent sampling performed in 2000 did detect PCBs; however, the actual concentrations could not be reliably measured (Weston 1999b, CH2M Hill and Baker 2000a, CH2M Hill and Baker 2003a).

As a precaution, based solely on the 2000 sampling results, the Navy advised people who fish on-base to not eat any fish from Youth Pond or Penniman Lake. Current or future exposures to fish are not expected to pose a health concern. People are not allowed to eat fish that they catch from the Youth Pond and Penniman Lake, where PCBs were measured in sediment. The contaminant concentrations measured in Cheatham Pond and Jones Pond are below levels where significant uptake by fish is not expected. People who consume fish from Cheatham Pond and Jones Pond are not expected to be exposed to contaminant concentrations in the fish at levels that could cause health concerns.

The Navy's advisory to not eat fish caught from Youth Pond and Penniman Lake stems from the ability of PCBs to accumulate in the tissue of some types of fish. However, fish tissue sampling was not performed, so it is not known if the fish from Youth Pond and Penniman Lake actually have accumulated PCBs. The extent to which accumulation occurs can vary widely depending on the type PCB present, the type of fish, and other environmental factors (ATSDR 2000c). While it is not possible to conclusively evaluate the potential exposure people could experience by eating fish from Youth Pond or Penniman Lake, it is likely that on-base residents and visitors did not eat enough fish from these two water bodies to cause any type of health concern. There is no past or current concern for people who eat fish from Cheatham Pond or Jones Pond.

In the future, if the Navy is considering lifting its prohibition on eating fish from Penniman Lake and Youth Pond, ATSDR recommends that fish tissue be sampled before any decision is made.

Potential Exposure to Contaminants Associated with the Penniman Shell Loading Plant

Nitroaromatics and some of the other contaminants detected in some areas of CAX are possibly due to activities associated with the Penniman Shell Loading Plant during and after World War I. This section describes the contaminants measured in the environment, available information describing the deposition of the remaining shells after the plant closed, and potential public health implications.

Background

DuPont operated the Penniman Shell Loading Plant in 1917 and 1918. The plant included three discrete areas, known as the "D" Plant, the Shipping Area, and the "G" Plant. Documentation of activities that occurred in these areas is incomplete.

The D Plant was northwest of Sanda Avenue, on both sides of Cheatham Pond. The Shipping Area was to the west of the D Plant. The D Plant was approximately 433 acres and included what was referred to as a TNT production area, pack houses, and two shell loading lines. There were

24 earthen bunkers in the TNT production area, some of which were used as nitro-starch dry houses, dry stores, and dynamite mix houses. Areas that were part of the D Plant are located on both Navy and NPS property. Navy IRP Sites 1, 2, 3, 4, 7, 8, and 9 and AOCs 3 and 5 are located within this general area.

The 515-acre Shipping Area is now entirely on NPS property. It included ammunition magazines and numerous blast holes. Some of the structures at the D Plant and the Shipping Area were as close as 40 feet from Cheatham Pond (Weston 1999a, b).

The G Plant was southeast of Sanda Avenue, entirely on Navy property. It included a 258-acre Shell Loading Area, with three shell loading lines. There were also eight concrete structures, described in engineering drawings from the World War I era as gauge pouring houses. The Navy currently uses these buildings for storage. Among the facilities within the G Plant were ammonia evaporating and finishing buildings, shipping houses, assembly houses, and areas where paint, TNT, and other compounds needed for the shell loading process were stored (Weston 1999a, b). The remains of some of these structures are still present.

EPA reviewed maps of and information about the locations of Penniman plant activities to select appropriate locations from which to collect soil, surface water, sediment, and background samples. Soil samples collected by EPA during the 1999 SI contained metals, PAHs, and nitroaromatics. Some of these contaminants were also detected in surface water and sediment samples, suggesting that contaminants might have been or might be migrating to nearby surface water bodies (Table 7) (Weston 1999a, b). The SI recommended additional sampling of all environmental media potentially impacted (including groundwater, which had not been sampled), along with completion of a human health risk assessment (CH2M Hill 2000; CH2M Hill 2002; Weston 1999b). To date, EPA has not undertaken this type of assessment or conducted further sampling.

When EPA added CAX to the NPL, it named five specific locations at the Penniman G Plant as potential sources of contamination. The Navy designated these sources as the Penniman AOC. The remainder of this section focuses on those five locations (sometimes referred to as sub-areas):

- TNT graining house sump
- TNT catch box ruins
- Ammonia settling pits
- 1918 drum storage area
- Waste slag material

The TNT graining house sump, TNT catch box ruins, and ammonia settling pits were along the southern shore of Penniman Lake, in an area that today is little-used and overgrown. The TNT graining house sump and catch box ruins were adjacent to each other. Both were used to separate TNT particles from wastewater, which was then discharged to Penniman Lake, approximately 25 feet away. Northwest of the TNT graining house, within 500 feet, were ammonia settling pits, which received wastewater from the ammonia finishing building and then discharged it to Penniman Lake, approximately 20 feet away (Weston 1999a, b).

Samples collected from the TNT graining house sump and the TNT catch box ruins contained TNT (and some of its breakdown products), PAHs, and metals at concentrations exceeding soil CVs. At the ammonia settling pits, only arsenic was present at a level exceeding its CV. One surface water and three sediment samples were collected from Penniman Lake, near the location where runoff from the three sites was suspected to enter the lake. No contaminants were present in the surface water or sediment samples at levels exceeding their CVs other than arsenic, which was measured only at relatively low levels. Contaminants detected in sediment samples at concentrations below CVs included SVOCs, pesticides, metals, and nitroaromatics. (While the sediment samples were analyzed for nitroaromatics, the surface water sample was not.) EPA did not attribute the arsenic or any other contaminants present in the Penniman Lake samples to the Penniman AOC locations that have been sampled. The Navy has proposed collecting and analyzing soil, surface water, sediment, and groundwater samples at all three sub-areas. VDEQ also supports additional investigations and remediation of these areas. While investigations are planned, they have not yet been scheduled (CH2M Hill 2002; Weston 1999a, b; Goodwin 1994; Willis 2004). Due to the continued interest in these areas by the Navy and regulators, ATSDR expects that the necessary investigations and remedial actions will occur before the land use changes are implemented that would allow greater public access to these areas.

At this time, the Navy, EPA, and VDEQ are still discussing what measures, if any, will be taken at the 1918 drum storage area and from areas affected by waste slag material. EPA identified the 1918 drum storage area from a 1918 photograph that showed wooden barrels and/or 55-gallon drums. The area depicted in the photograph was south of Sanda Avenue, near its intersection with B Street. Samples collected there contained only arsenic at levels above its CV. Waste metallic slag is scattered throughout the shell loading area, predominantly along former railroad beds. Some slag is present on what is now NPS property. An NPS employee speculated that the slag was broken out of boilers on locomotives while the Penniman plant operated. EPA samples were collected east of AOC 2, near the bend in Garrison Road, and contained elevated concentrations of five metals (CH2M Hill 2002; Weston 1999a, b).

During its 1999 investigation, EPA also collected soil samples from two other locations within the G Plant and three locations on NPS property that were within either the Penniman D Plant or the shipping area. The two potential sources of contamination sampled within the G Plant were (1) an underground mixing tank and (2) the opening of a pipe that runs between the TNT graining house and the ammonia evaporating building. The samples in the tank area contained concentrations of arsenic, lead, and PAHs exceeding CVs. A soil sample near the pipe opening contained arsenic at a level that exceeded the CV. No nitroaromatics were detected. One of three areas sampled on NPS property was near bunkers where nitro-starch was dried; associated sump pits and sediment from a nearby drainage way were also sampled. No contaminants were present at concentrations exceeding CVs. EPA also identified more than 100 blast holes 10 to 25 feet in diameter and up to 6 feet deep on NPS property and collected two samples within the holes. The blast holes are thought to have been created from quality control detonations of packed shells. Soil samples collected there contained two metals at levels exceeding CVs. Finally, two samples were collected near a heavily-reinforced drum on NPS property that was thought to have contained an agent that generates smoke. Two pesticides and two PAHs were present at concentrations exceeding CVs (Weston 1999a, b).

Information about the disposition of ordnance, explosive materials, and other compounds handled at the Penniman Shell Loading Plant after World War I ended is limited. An EPA review of available documents associated with Penniman activities summarizes the information in a 1999 "Data Acquisition/Summary Report." Records indicate that the U.S. government sent DuPont instructions modifying the processes used to prepare and store ordnance and explosives in December 1918. DuPont reportedly decommissioned shells through February 1919. DuPont also dismantled the plant and salvaged certain materials used there (Weston 1999a; Goodwin 1994).

Beginning in late 1918 or early 1919, the U.S. government operated the Penniman General Ordnance Depot in part of the area that the Penniman plant had occupied. Little information is available about operations at the depot. Workers there were charged with sending an estimated 5 million pounds of ammonium nitrate present at the Penniman plant to a company in North Carolina. The last shipment of ammonium nitrate was reportedly sent in 1920. EPA also notes that in 1923, almost 50,000 155-millimeter shells were shipped to another U.S. ordnance depot (known as Pig Point at that time, but later renamed Nansemond Ordnance Depot) in Virginia. The Penniman plant loaded five sizes of shells and reportedly had the capacity to load approximately 54,000 shells per day. EPA could not locate information about the disposal of shells of the other four sizes (and any additional 155-millimeter shells) (Weston 1999a).

Records about materials handled at the former Nansemond Ordnance Depot also indicated that some shells from the Penniman plant were shipped there after the war and that the plant received substantially fewer shells than what would have been present at the Penniman plant at the end of the war. According to EPA, other ammunition expected to have been present at that time has not been accounted for. It may have all been shipped off site. Or, some of it may have been burned. Ground scarring evident in subsequent aerial photographs may have been caused by burning activities. Some of it may have been melted for reclamation or been buried. While documentation describing the final disposition of the remaining ammunition is incomplete, there is no specific evidence pointing to on-site disposal (EPA 2003a).

Discussion

Some soil and sediment samples collected by EPA since the 1980s to characterize areas most likely to be impacted by Penniman-related activities have contained elevated concentrations of metals, PAHs, and nitroaromatics. However, in most locations the contaminants have been detected at low levels, below CVs. The highest levels of contaminants were observed at the TNT graining house sump, TNT catch box ruins, and the slag area. Sampled locations were selected in part because they might contain some of the highest levels of contaminants still present. It is unlikely anyone is regularly exposed to any of the source areas sampled. The TNT graining house sump, catch box ruins, and slag area are not easily accessible. They are not close to common recreational destinations like camp sites and picnic areas, and they are amidst thick vegetation. Potential contact with this area by base residents or visitors is expected to be incidental, rather than frequent or for long periods of time. On-base residents or visitors may be able to come into contact with contaminants at these locations, however no adverse health effects are expected because the contact would be both infrequent and for short periods of time.

Additional environmental investigations or remedial actions may be necessary if land use changes occur which allow greater public contact with the area containing the TNT graining house sump and catch box ruins.

There are no data about contaminant levels present at the time Cheatham Annex opened or in the decades that immediately followed. Given the history of the site, contaminant levels may have been higher in the past, so ATSDR cannot definitively evaluate past exposures. However, there is no information to indicate that frequent contact by on-base residents or visitors would have been likely following the end of the Penniman operations. It is likely that past exposures to soil contaminants would have been incidental, as it is now, and no adverse health effects are expected due to past contact with soil contaminants at these sites.

Some of the ordnance that would have been present at the Penniman plant at the time World War I ended has not been accounted for in the available records. It may have been transported off-site, buried, melted and/or burned. No buried ordnance has been encountered at CAX or areas once part of CAX that have been transferred to other agencies. Historical aerial photographs have not shown any locations at CAX or nearby property with where there were remains of shells or associated materials from World War I or any ground scarring conclusively attributed to burning ordnance. Although all of the former Penniman property has not been thoroughly searched, none of the investigations conducted by EPA, the Navy, and the other agencies that hold nearby parcels have revealed any ordnance. However, EPA has recommended that some areas continue to be evaluated for possible buried explosive materials (EPA 2003b). ATSDR concurs with those recommendations. ATSDR also acknowledges that there will likely always be some uncertainty about how some of the ordnance was disposed of and that new information may become available in the future. If requested, we will review any additional data after it becomes available, if it is likely to modify this health evaluation.

Potential Exposure to Physical Hazards At and Near CAX IRP Sites

ATSDR identified two locations with potential physical or safety hazards. Both are in areas that base residents or visitors might encounter (one is near Youth Pond and the other is near cabins by the York River). The Navy has not reported to ATSDR any occasions during which people were injured at these locations. Recent and planned actions are expected to address these issues and ultimately eliminate the safety hazards.

Buried Medical Waste; Sharps from Site 4

The Navy previously disposed of out-of-date medical supplies, including syringes and empty intravenous bottles, in a depression adjacent to an unnamed pond, within the fenced-in warehouse area of CAX. The waste, as much as 7,000 cubic yards, was then covered with soil. Sometime before 1984, a considerable volume of this waste was removed from the site. Nevertheless, after heavy rains, syringes were reportedly sometimes seen floating in the unnamed pond, Youth Pond (which is outside of the fenced-in area and immediately downgradient of the unnamed pond), and a culvert where water from Youth Pond drains to the York River. During May 1998, approximately 215 pounds of debris and sharps were removed from the surface of Site 4 (CH2M Hill 2000; Baker 2003).

Particularly before the 1998 removal action, sharps, glass bottles, and certain other types of medical supplies that were washed outside the fenced warehouse area posed a safety hazard to Navy personnel and their families visiting affected areas. Medical supplies in Youth Pond were of particular concern for children of on-base residents or visiting families who may have used the pond for recreational activities. However, no past injuries were recounted to ATSDR.

The Navy investigated the extent of remaining contamination in 2001 and plans to evaluate remedial options to prevent the remainder of buried waste from being transported off site and into the ponds (CH2M Hill 2000; Baker 2003). Although the previous removal actions significantly reduced the potential for waste transport into Youth Pond, the remaining waste still represents a potential physical hazard. ATSDR recommends that the Navy complete the remedial actions necessary to prevent additional waste transport from the burial site.

Damaged fence near the rental cabins; Sites 7 and 13

Within the main part of CAX, near the edge of a cliff by some recreational cabins, there are two discrete disposal areas. The IAS indicated Site 7 had received waste from the Penniman Plant and the City of Penniman but did not provide details about the types of waste present, other than that it included ammunition waste. Site 7 was reportedly located between two cabins along the York River. In 1999, the Navy investigated a disposal area in the same approximate area and found that at least some of the waste present post-dated World War I. In 2000, the Navy discovered a nearby dump site that it determined was the one described in the IAS. It was located between the cabins and the York River on a steep bank about 20 feet above the water surface. This site was designated Site 13. In the future, the Navy plans to address Site 13 along with the nearby Site 7 area (CH2M Hill and Baker 2001a).

The Navy installed a fence to keep recreational users from getting too close to the cliff; it was not erected to keep people from coming into contact with the buried debris (CH2M Hill and Baker 2001a). In September 2003, heavy rainfall from Hurricane Isabel caused extensive erosion of the cliff along the York River, near Sites 7 and 13. Due to the soil erosion, the fence installed by the Navy now dangles over the cliff drop-off in some places. Some of the waste present at that time may have been carried into the York River (Harlow 2003b). Because more than half a dozen cabins are located nearby, visitors may frequent this area. The two cabins closest to the cliff are no longer being used and will be moved elsewhere within CAX. However, additional cabins approximately 100 yards away are still being used (Bond 2004).

ATSDR is concerned that children may be tempted to play near the fence and possibly slip under the dangling fence. If so, there is a risk that they might come into contact with waste or that they may come too close to the edge of the cliff. Therefore, the dangling fence poses a potential safety hazard. The Navy indicated it plans to fix the fence, but this had not occurred as of May 2004.

ATSDR recommends that the fence be repaired as soon as possible or that other measures be taken promptly to reduce this hazard.

The Navy is also evaluating how to remediate the waste still present, which is complicated by the fact that not all the waste has been characterized. A variety of different waste could be considered ammunition waste, and no information about the types of materials dating back to the Penniman era that are present is currently available. Therefore, ATSDR cannot evaluate the potential for waste material to pose a physical hazard. Future investigations and remediation of disposal sites will be conducted by the Navy and overseen by EPA and VDEQ. This work is expected to be carried out in a manner that protects residents and visitors from coming into contact with any physical hazards that may be posed by the waste associated with ammunition.

Potential Exposure to Contaminants at the Fuel Farm

Background

A 460-acre area, now known as the Fuel Farm, is located south of the Colonial National Historical Parkway, east of Highway 199, and west of Burma Road. Limited historical records of Penniman activities suggest that a hospital was located in the area that later became the Fuel Farm (Weston 1999b). Aerial photographs from the 1920s and 1930s show ground scarring in this area, which may indicate of burning activities (EPA 2003a). In the 1940s, the Navy installed 18 concrete underground fuel storage tanks (USTs). During the Korean War, another five steel tanks were installed. The tanks each have the capacity to hold approximately 2 million gallons of fuel. Fuels stored included No. 2 fuel oil, kerosene, gasoline, and aviation fuels (ATSDR 2000a; VIMS 1994).

Beginning in 1973, the Commonwealth of Virginia leased the facility to store fuel during the energy crisis. The Commonwealth bought the Fuel Farm from the Navy in 1981 but closed it in 1982. The tanks were disconnected from several miles of fuel delivery pipelines, and the pipelines were capped. All 23 fuel tanks were cleaned out in 1992, and delivery pipelines were fully cleaned in 2002 (ATSDR 2000a; EPA 1997b). Abandoned fuel drums and cans were removed. There were some transformers and other on-site equipment containing PCBs, but were removed, and PCB contamination was remediated (EPA 1997b; EPA 2003b).

Fuel releases over time contaminated surface and subsurface soil, sediment, and groundwater at the Fuel Farm with petroleum hydrocarbons (EPA 1997b). According to summary information, five separate plumes of groundwater contamination containing benzene, toluene, ethylbenzene, xylenes (BTEX), and other contaminants have been identified at the site. BTEX compounds exceed EPA's MCLs in the centers of the groundwater plumes. Groundwater contamination does not extend beyond the Fuel Farm boundaries, it remains within the northern part of the site and has stabilized naturally (EPA 1999a, b). When sampled around 1990, off-site monitoring wells west of the Fuel Farm were not affected by fuel-related contamination (VIMS 1994). A long-term monitoring program is in place to track the extent to which contaminant levels in soil and groundwater decline as a result of natural attenuation or degradation. Surface water in an on-site pond, Hipps Pond, and its two tributaries have BTEX concentrations slightly above CVs.

Sediment in the pond and tributaries remains heavily contaminated, particularly with PAHs (EPA 1999a, b).

Approximately 200 acres of the 460-acre Fuel Farm are contaminated. In 1997, EPA and the Commonwealth of Virginia agreed to a final remedy for the Fuel Farm property. Remedial actions included: 1) an upgrade to the dam at the outlet of Hipps Pond, to prevent contaminated sediments from being washed downstream; 2) the excavation and removal of a sludge pit and a Cosmoline (a jelly-like preservative) dump; 3) remediation of an additional sludge pit; 4) long-term groundwater monitoring; and 5) installation of a fence and warning signs to prevent public access to the contaminated portion of the property. By August 2002, all construction activities associated with the remedy had been completed, including the installation of a perimeter fence (EPA 2003d; Noel 2003).

The York County Industrial Development Authority (IDA) has promoted construction of a golf course on approximately 260 acres in the northern part of the former Fuel Farm property (separated from the southern portion by a line roughly parallel to the Colonial National Historical Parkway). The approximately 200 acres contaminated by past fuel storage fall within the 260-acre proposed golf course site (York County Public Information Office 2002; Noel 2003). The contaminated area is subject to a Corrective Action Plan to address hydrocarbon contamination. Creation of a golf course is consistent with the requirements of this plan and is considered a "brownfields" project, because it entails redevelopment of an idle property affected by past contamination.

The York County Comprehensive Plan calls for commercial development in the southern, uncontaminated part of the Fuel Farm. The County indicates that no residential development is planned (Noel 2003; York County Planning Division 1999). The IDA is marketing approximately 80 acres within the uncontaminated portion of the Fuel Farm to commercial interests (and to parties who conduct light industrial activities). So far, a 15-acre parcel has been earmarked for office and storage space for one future tenant. Many of the remaining 120 acres in this portion of the Fuel Farm are wetlands and ravines and are not well-suited to development (Noel 2003; York County Office of Economic Development n.d.).

Discussion

There is no indication that anyone will be exposed to contaminated groundwater, because the groundwater contamination is confined to the northern part of the site, and there are no residences or drinking water wells in that area. The public water supply from Newport News has been extended and will provide drinking water to any future facilities constructed at the Fuel Farm (Noel 2003). The perimeter of the Fuel Farm is currently fully fenced, preventing public access to on-site soil or to Hipps Pond surface water or sediment. There was no public access to the site in the past, when the Navy and then the Commonwealth of Virginia used it for fuel storage. Any unauthorized access during those time periods or afterwards, before the perimeter fence was secured, would probably have been very limited, if it occurred at all, as there are other areas nearby that are open to the public for recreational use (such as National Park Service land and the County park). As a result there is no significant exposure to potential soil contaminants.

Planned remedial actions are expected to ensure that future users will not be exposed to Fuel Farm-related contaminants at levels that could cause health effects.

ATSDR expects that if evidence of previously buried Penniman-era materials are discovered during the re-development, EPA and VDEQ approved remedial actions will prevent exposures that could result in adverse health effects for future users of this area. If requested, ATSDR will review any additional data after it becomes available, if it is likely to modify this health evaluation.

Community Health Concerns

During our discussions with Navy, EPA, and VDEQ personnel during the site visit and subsequently, as well as our review of site-related documents (including the Community Relations Plan), ATSDR inquired about community concerns associated with CAX. We identified a community concern about consuming locally-caught seafood, which we address below. During our work on other Navy facilities in the Hampton Roads area, ATSDR became familiar with regional concerns about childhood lead poisoning, which we also address in this section.

Is it safe to eat locally-caught seafood?

A common community concern questions the safety of eating locally-caught seafood (from water bodies outside of CAX). Because of the variety of military installations, industrial facilities, and other potential sources of contamination in the area, some people are concerned that local finfish and shellfish may have measurable levels of contaminants in their tissues. ATSDR reviewed the available information to address this concern. Because the condition of the waterway may change over time, *ATSDR recommends that people review relevant fishing advisories for the areas where they intend to fish.*

There are no fishing advisories for the York River or its tributaries to prohibit or restrict fishing. VDH and EPA offer general fishing advisories to inform people about how to select and prepare fish they catch in a manner that reduces potential exposures to some types of contaminants. ATSDR recommends that people review these advisories, which can be found on the EPA and VDH Internet sites or obtained by contacting the agencies directly. (EPA recommendations: http://www.epa.gov/waterscience/fish, includes a link to *A Guide to Healthy Eating of the Fish You Catch,* [http://www.epa.gov/waterscience/fish/30cwafish.pdf]; VDH recommendations: http://www.vdh.state.va.us/hhcontrol/fishing_advisories.htm.)

ATSDR evaluated fish sampling data from the Virginia Institute of Marine Sciences (VIMS) (Appendix E). The sampling area predominately consisted of waterways associated with the James and York rivers, from the mouth of the Chesapeake Bay and upstream to approximately Williamsburg, VA. Waterways between Norfolk and Virginia Beach, VA, and the inland portion of Cape Charles were also represented. The sampling data were gathered between 1997 and 2001. The samples primarily consisted of skin-off fillets of finfish. Results of the evaluation indicate that there are no health concerns for people who consistently consume one to two 8-oz fish fillets per week from the sampled area. Eating more fish will increase a person's potential exposure to PCBs. All fish consumers, and especially people who routinely consume two or more 8-oz fish fillets per day may want to consider reducing their potential PCB exposure by: 1) selecting the younger, smaller fish of a species (within legal limits), 2) removing the skin, belly fat, and internal organs prior to cooking, 3) baking or broiling the fish fillets, and 4) not eating the fatty juices or drippings.

Are children who live at Cheatham Annex exposed to potentially dangerous levels of lead?

The Navy has made a concerted effort to assess and address any damaged lead-based paint in Navy family housing areas and provide Navy families with information about lead exposures. It is Navy policy to screen young children who are at risk for childhood lead poisoning, consistent with CDC recommendations. ATSDR has requested the lead management plan for Cheatham Annex and will discuss its findings in this section upon receipt of that document and any associated information the Navy can provide.

Child Health Considerations

ATSDR recognizes that infants and children may be more sensitive to exposures than adults in communities with contamination in water, soil, air, or food. This sensitivity results from a number of factors. Children are more likely to be exposed because they play outdoors and often bring food into contaminated areas. Children are shorter than adults, and may breathe dust, soil, and heavy vapors close to the ground. Children are also smaller, potentially resulting in higher doses of chemical exposure per unit body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. Therefore, ATSDR is committed to evaluating their special interests at sites such as Cheatham Annex as part of the ATSDR Child Health Initiative.

Approximately 172 children aged 6 years or younger live within 1 mile of Cheatham Annex. There are no on-base child care facilities or schools. Children living at CAX would be likely to play in areas near the family housing units. Children would also be expected to visit the picnic area near the bachelors' quarters, the campground east of the Penniman Lake, and on-site cabins.

Children may contact soil, surface water, or sediment contaminants. To evaluate whether children may experience adverse health effects through past, current, or future exposures to site contaminants, ATSDR estimated the potential doses for children. To estimate these doses, ATSDR used assumptions that are considered to be protective for children, based on our understanding of actual exposure conditions. *ATSDR concluded that current and future exposure to site contamination at Cheatham Annex does not pose unique health hazards for children.* Due to a lack of historical data, it is not possible to evaluate potential past exposures. However it is likely that these exposures were infrequent and occurred only for a short period of time and did not pose a health concern.

Conclusions

Based on the evaluation of available exposure and health effects information, ATSDR drew the following conclusions:

1. Current sources of air emissions were not identified at CAX. Past air emission sources include an incinerator which apparently operated between 1942 and 1951. Little information is available about the actual time period it operated or how it was used. As a result it is not possible to evaluate whether people could have been affected by past releases. Past exposure to incinerator emissions were classified as an *indeterminate public health hazard.* Current exposure to on-base emissions were classified as *no public health hazard.*

2. Drinking water at Cheatham Annex, currently and in the future, poses no public health hazard. Since 2002, drinking water has been supplied by the Newport News Waterworks, which draws water from sources outside of Williamsburg, treats it, and samples it regularly. Current and future used of on-base drinking water was classified as *no public health hazard.*

3. Past exposure to drinking water at CAX, which came from Jones Pond and was treated at Cheatham Annex's water treatment plant before being distributed, can not be conclusively evaluated. Nitroaromatics were detected at trace levels in 1999 and 2000 samples from Jones Pond. No samples had been analyzed for nitroaromatics in preceding years, when levels of nitroaromatics may have been higher. EPA indicates that some waste at nearby AOC 1 dated back to the Penniman era. Nitroaromatics were also measured in sediment in a tributary to Jones Pond that receives drainage from AOC 1. Without information about the levels of nitroaromatics to which people were exposed in the past, ATSDR cannot draw conclusions about past exposure to drinking water. Past use of on-base drinking water was classified as an *indeterminate public health hazard.*

4. Past, current, and future exposures to surface water and sediment at the four on-site water bodies at CAX pose no apparent public health hazard. Because swimming is prohibited, the only exposures would be contact with small amounts of sediment or surface water during other recreational activities. Contaminant levels measured in the ponds have been relatively low, and the detected concentrations would not cause adverse health effects recreational users of the on-base ponds and lakes. Past, current and future exposure to on-base surface water and sediment was classified as *no apparent public health hazard.*

5. Past, current and future exposures to fish caught from Cheatham Pond and Jones Pond pose no apparent public health hazard. While no fish tissue samples are available, contaminant concentrations measured in surface water and sediment in those ponds have been fairly low. No PCBs were detected in sediment from both water bodies. These data suggest that contaminant levels in fish would likely be lower than those that could cause adverse health effects. Eating fish caught from Cheatham Pond and Jones Pond was classified as *no apparent public health hazard.*

6. Past exposure to fish caught from Penniman Lake or Youth Pond poses an indeterminate public health hazard. Until 2000, Navy families were allowed to eat fish from not only Cheatham Pond and Jones Pond, but also Penniman Lake and Youth Pond. Levels of PCBs in sediment samples collected from Penniman Lake and Youth Pond in 2000 were elevated, which is why the Navy advised residents and visitors not to eat fish from those two ponds. Because no fish tissue samples are available, ATSDR cannot draw conclusions about past exposure to fish from Penniman Lake and Youth Pond. Recreationally-caught fish typically make up only a very small portion of people's diets, therefore, it is likely that people did not eat enough fish from Penniman Lake or Youth Pond to result in a PCB exposure that could cause health concerns. However because there is no fish tissue sampling data to verify this expectation, eating fish caught from Penniman Lake or Youth Pond was classified as an *indeterminate public health hazard.*

7. Current exposures to soil contamination identified on-base pose no apparent public health hazard. Any exposure to affected areas would likely be incidental and infrequent. Sampling conducted by EPA in 1999 did not reveal contaminants present in soil at sufficiently high concentrations that adverse health effects would result, given current exposure scenarios. Additional environmental investigations or remedial actions may be necessary if land use changes occur which allow greater public contact with the area containing the TNT graining house sump and catch box ruins. Current exposure to soil was classified as a *no apparent public health hazard.*

8. No soil sampling data was collected prior to the 1990s. As a result ATSDR cannot draw definite conclusions about the past exposure to soil contaminants. However, it is expected that past exposures to soil contaminants for on-base residents and visitors was similar to the exposures identified for current on-base residents and visitors; that they had only minimal and infrequent contact with soil contaminants. As a result it is expected that the potential exposure for past on-base residents and visitors would not be expected to cause health concerns. Past exposure on on-base residents and visitors to soil was classified as a *no apparent public health hazard.*

9. Information about decommissioning and disposal of shells and explosives after the Penniman Shell Loading Plant closed is incomplete. Some of the ammunition expected to have been present when World War I ended has not been accounted for. While not all of the areas used during the Penniman-era have been thoroughly investigated, none of the environmental investigations that have been conducted have identified ordnance at CAX, on National Park Service land that was previously part of the Penniman plant, or at the Fuel Farm. Because no evidence of shells or explosives has been identified during environmental investigations to date, ATSDR classified the past exposure to Penniman-related explosive materials as *a no apparent public health hazard.*

10. Because there is some uncertainty associated with how ordnance was disposed of and if ordnance or explosive materials could be found in the future, ATSDR classified the current and future potential exposure to shells and explosives as an *indeterminate public health hazard.* ATSDR acknowledges that future investigations may identify new

information. If requested, we will review additional data after it becomes available, if it is likely to modify this health evaluation.

11. In the past, medical supplies originally buried at Site 4, including syringes, were washed into Youth Pond via an upgradient pond adjacent to Site 4. Youth Pond and the surrounding area are used by families with children visiting or residing at CAX, and the waste is a potential safety hazard. A removal action was conducted in 1998. In 2001 the Navy investigated the remaining waste to evaluate how to prevent additional transport into the ponds or off site. The remaining waste still represents a potential physical hazard. ATSDR recommends that the Navy complete the remedial actions necessary to prevent additional waste transport from the burial site.

12. Heavy rainfall from Hurricane Isabel (in September 2003) caused extensive erosion of the cliff along the York River, near Sites 7 and 13. Due to this soil erosion, the fence installed by the Navy to prevent cabin visitors from moving too close to the cliff now dangles over the drop-off in some places. The concern is that children may be tempted to play near the fence and possibly slip under the dangling fence and exposed to potential safety hazards associated with the waste and the cliff. The Navy plans to repair the fence, but had not done so as of May 2004. ATSDR recommends that the fence be repaired as soon as possible or that other measures be taken promptly to reduce this hazard.

13. Contaminated soil and groundwater at the former Virginia Fuel Farm pose no apparent public health hazard because no one is exposed to groundwater and secure fencing has kept trespassers from coming into contact with contaminated soil. A remediation plan is in place to address the contamination from the previous Fuel Farm activities. ATSDR expects that if evidence of previously buried Penniman-era materials are discovered during the re-development, EPA and VDEQ approved remedial actions will prevent exposures that could result in adverse health effects for the future users of this area. If requested, ATSDR will review any additional data after it becomes available, if it is likely to modify this health evaluation. ATSDR classified the past and current exposure to soil and groundwater at the Fuel Farm as a *no apparent public health hazard.*

Recommendations

1. If the Navy is considering removing the restrictions on eating fish from Penniman Lake and Youth Pond, ATSDR recommends that the Navy first analyze fish tissue samples from those two water bodies.

2. ATSDR recommends that the Navy complete remedial actions necessary to prevent additional waste transport from Site 4 into areas accessible to residents and visitors, particularly Youth Pond.

3. Children playing by the broken fence near the cabins by the York River could fall from the nearby cliff. To eliminate this safety hazard, ATSDR recommends that the fence be repaired as soon as possible or that other measures be taken to prevent people from coming into contact with these physical hazards.

4. ATSDR recommends that additional studies and/or remedial actions be considered if redevelopment of areas potentially impacted by Penniman-related activities is planned.

Public Health Action Plan

The Public Health Action Plan (PHAP) for Cheatham Annex contains a brief description of some of the actions that have been taken or will be taken by ATSDR, the Navy, EPA, and VDEQ. The purpose of the PHAP is to ensure that this PHA not only identifies potential and ongoing public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The public health actions that are completed, ongoing or planned are listed below.

Completed Actions:

1. In 1999 and 2000, debris present on the beach area along the northeast perimeter of Site 1 was removed. During the summer of 2003, the Navy removed approximately 20,000 cubic yards of contaminated soil, landfill material, and debris from this site. A draft RI was issued in 2002.

2. In 1998, the Navy removed approximately 200 pounds of surface debris and 13 pounds of sharp metal and plastic items from Site 4 and incinerated them. The Navy investigated the extent of contamination at this site in 2001 and recommended an engineering analysis/cost analysis (EE/CA) be completed to assess ways to remediate this site and prevent buried materials from being washed into nearby ponds. The Navy has also submitted a draft ecological risk assessment for this site.

3. In 1999, 10 test pits were excavated at Site 7 to try to determine where debris was buried, after which the pits were backfilled.

4. As a result of a VDEQ and EPA recommendation in 2000, the Navy drafted an ecological risk assessment for Site 9.

5. In December 1985, the Navy conducted a magnetometer survey at Site 10, but no magnetic anomalies reflecting buried containers were found. The Navy further investigated the site in 1992 and 1997 and is not planning any further work there.

6. In 1987 and 1997, drums and tanks were removed from Site 11, which had been used to dispose of oil, asphalt, tar, barrels of gasoline, etc. Another approximately 60 tons of material was also removed and disposed of as non-hazardous waste. Surface water, sediment, groundwater, soil gas, and drum samples were collected as part of various site investigations in 1986, 1988, 1992, and 1997. The Navy has submitted a draft ecological risk assessment for this site.

7. In 1999, a geophysical survey and soil, surface water, and sediment sampling took place at AOC 1.

8. AOC 2 was investigated in 1998, 1999, and 2001, and hundreds of bottles containing dextrose, as well as 43 empty drums, have been removed and disposed of off site. In

addition, an unspecified number of respirator cartridges—but not all—were found and removed.

9. In 2003, the Navy assigned No Further Response Action Planned status to Sites 2, 3, 5, 6, 8, and 10.

Ongoing or Planned Actions:

1. The EPA continues to support efforts to evaluate if additional physical hazards exist at CAX due to the historic Penniman activities.

2. If requested, ATSDR can review additional data after it becomes available, if it is likely to modify any of these health evaluations.

3. The Navy is planning to release a final draft of a report describing background conditions across CAX.

4. Ecological risk assessments for several IRP sites will be produced.

5. The Navy expects to release a final RI for Site 1.

6. According to the Navy, further investigation and possible removal of sources of contamination may be required at Site 7, and a future investigation is planned.

7. Surface water and sediment samples have been collected recently at Site 11, but results are not yet available. A draft RI report is in progress, but has not yet been issued.

8. A limited field investigation is in progress at Site 12, and a report documenting its findings will be produced.

9. The Navy is planning to investigate contamination at Site 13, which will be addressed jointly with Site 7. Access to much of the debris at this site had been limited by a fence, which was damaged by Hurricane Isabel in September 2003. The hurricane also eroded a cliff, which is about 20 feet above the York River, as a result of which some portions of the fence dangle over eroded portions of the cliff. The Navy plans to repair the fence.

10. Additional investigation is planned at AOC 1, and the Navy also plans to conduct a limited investigation to evaluate disposal options for contaminated media.

11. The Navy plans to conduct an EE/CA as part of determining additional actions to take at AOC 2.

12. AOC 3 is scheduled for an EE/CA and removal action.

13. An investigation is planned for the Penniman AOC.

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Appendices

Appendix A — Figures

FIGURE 1.
CHEATHAM ANNEX and VICINITY

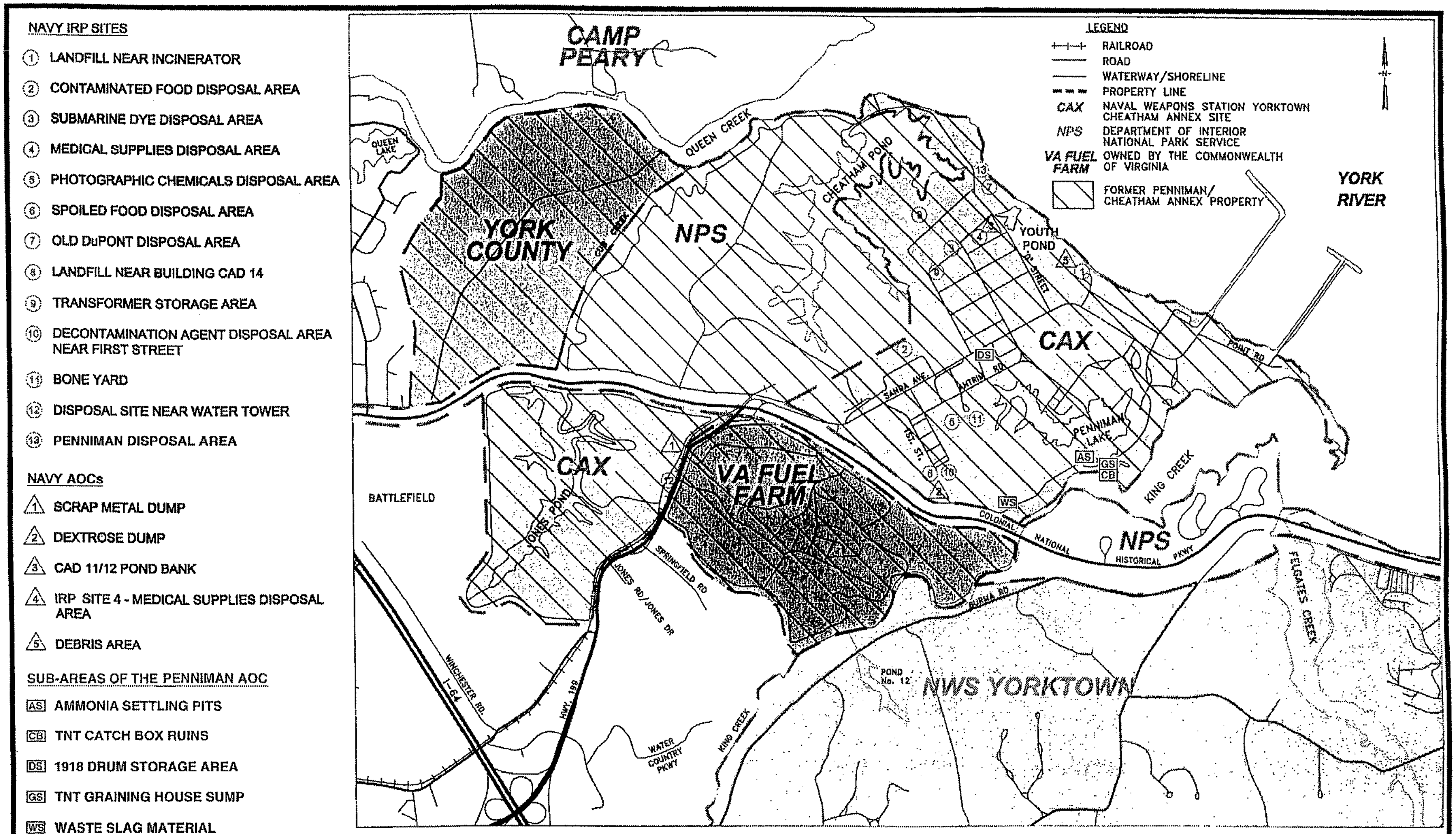


FIGURE 2.
CURRENT AND PAST PROPERTY OWNERSHIP, WITH INSTALLATION RESTORATION PROGRAM (IRP) SITES AND AREAS OF CONCERN (AOCs)

Source: CH2M Hill 2000

210450OM

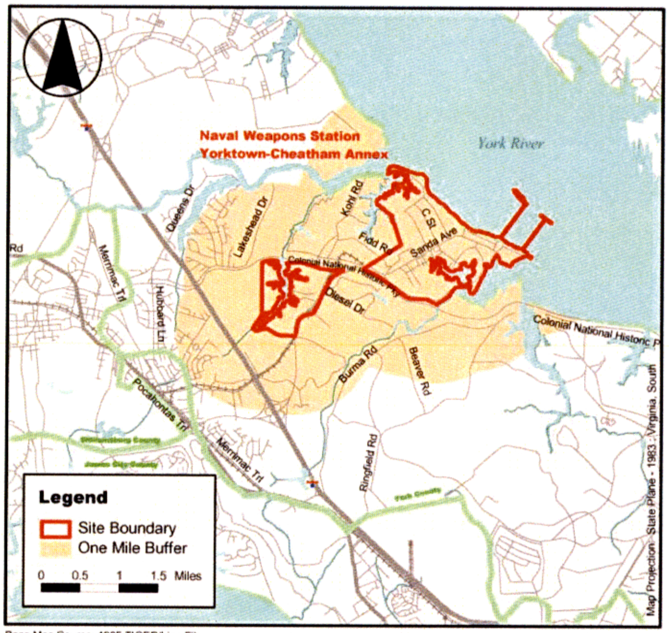
Figure 3. Demographic Data

Naval Weapons Station Yorktown-Cheatham Annex

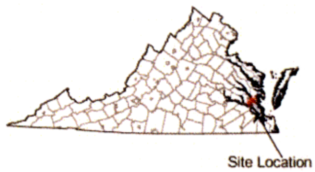
INTRO MAP

Williamsburg, Virginia

EPA Facility ID VA3170024605



Base Map Source: 1995 TIGER/Line Files

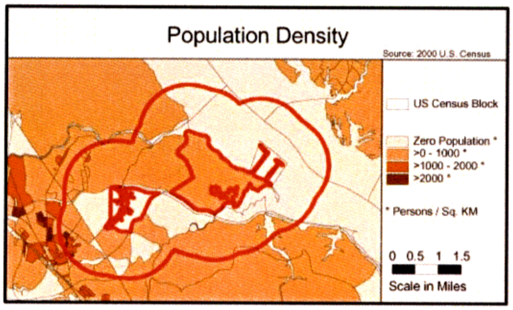


York County, Virginia

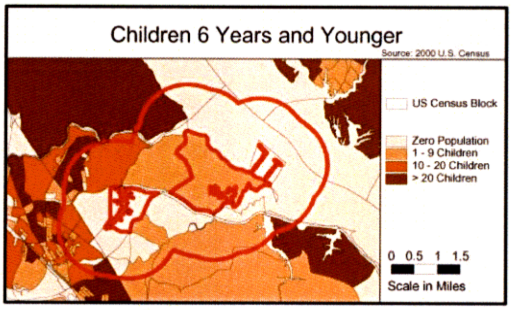
Demographic Statistics Within One Mile of Site*	
Total Population	2416
White alone	1641
Black alone	651
Am. Indian and Alaska Native alone	3
Asian alone	59
Native Hawaiian and Other Pacific Islander alone	2
Some other race alone	18
Two or More races	42
Hispanic or Latino	42
Children Aged 6 and Younger	172
Adults Aged 65 and Older	393
Females Aged 15 - 44	465
Total Housing Units	893

Demographic Statistics Source: 2000 US Census
*Calculated using an area-proportion spatial analysis technique

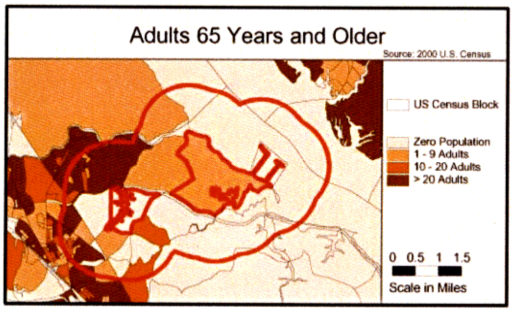
Population Density



Children 6 Years and Younger



Adults 65 Years and Older



Females Aged 15 - 44

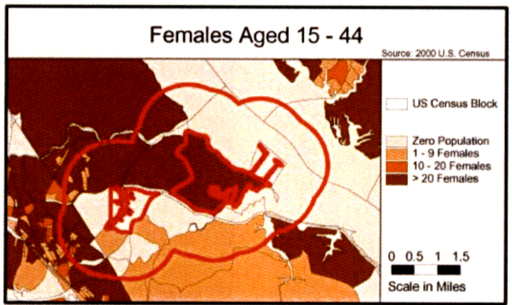


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Figure 4: ATSDR's Exposure Evaluation Process

REMEMBER: For a public health threat to exist, the following three conditions must all be met:

- Contaminants must exist in the environment
- People must come into contact with areas that have potential contamination
- The amount of contamination must be sufficient to affect people's health

Are the Environmental Media Contaminated?

ATSDR considers:

Soil
Ground water
Surface water and sediment
Air
Food sources

Are People Exposed To Areas With Potentially Contaminated Media?

For exposure to occur, contaminants must be in locations where people can contact them.

People may contact contaminants by any of the following three exposure routes:

Inhalation
Ingestion
Dermal absorption

For Each Completed Exposure Pathway, Will the Contamination Affect Public Health?

ATSDR will evaluate existing data on contaminant concentration and exposure duration and frequency.

ATSDR will also consider individual characteristics (such as age, gender, and lifestyle) of the exposed population that may influence the public health effects of contamination.

Appendix B — Tables

Table 1. Evaluation of Potential Exposure Pathways at Cheatham Annex

Pathway Name	Exposure Pathway Elements					Time of Exposure	Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population		
Drinking water	Navy and Penniman Shell Loading Plant operations and waste management at Cheatham Annex (CAX)	Surface water drawn from Jones Pond	CAX taps and any taps at areas formerly part of CAX (e.g., at the Fuel Farm) that received drinking water from the Jones Pond treatment plant	Ingestion Inhalation Dermal contact	CAX employees, residents, and visitors	Past	**Past:** Jones Pond was the source of drinking water at CAX from the 1940s through 2002. Water was processed at a treatment plant and tested for chlorination byproducts and physical parameters before being distributed. Periodically, treated water was also sampled for common chemical contaminants, such as metals and VOCs; the measured concentrations have been consistently within regulatory limits since at least 1993. The few available samples from Jones Pond and nearby drainage ways contained low levels of metals and explosive compounds (nitroaromatics). Samples collected at the treatment plant were not analyzed for nitroaromatics. The nitroaromatics may have originated from Penniman-era wastes found in the nearby AOC 1. The concentration of nitroaromatics in the sediment and surface water were well below levels of concern for drinking water at the time of the sampling (1999-2000) and likely for the recent past. However no sampling information in available to identify whether nitroaromatic were present in the drinking water in the past. **Current/Future:** CAX currently receives water from the City of Newport News, which draws water from sources more than 4 miles from CAX. Newport News treats its drinking water before distributing it and analyzes samples regularly. Because Jones Pond is no longer used as a drinking water source, there is no exposure to contaminants in Jones Pond and therefore no risk of adverse effects.

Table 1. Evaluation of Potential Exposure Pathways at Cheatham Annex (continued)

Pathway Name	Exposure Pathway Elements: Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population	Time of Exposure	Comments
Air	Past air emissions	Air	Locations downwind of past sources of air emissions	Inhalation	CAX and nearby employees, residents, and visitors	Past	**Past:** Navy documents indicate that there was an active incinerator at CAX (incinerator waste was buried at Site 1 from 1942 to 1951). Little is known about the nature and quantity of material incinerated, how often the incinerator was used, or when burning activities ended; however the incinerator was dismantled around 1990. Navy bachelor housing is approximately ½ mile or more from the incinerator, and family housing units still in use are at least 1 mile from the incinerator. There are no records of the actual emissions from the incinerator, so it is not possible to estimate if people could have been affected by the emissions. However, emissions usually disperse quickly in air, greatly reducing the potential for health effects to people living on or visiting CAX.
Soil	Operations and waste management at CAX, waste associated with former Penniman Shell Loading Plant	Soil	Locations where soil was contaminated by Navy or Penniman activities	Ingestion Dermal contact	CAX and nearby employees, residents, and visitors	Past Current Future	**Past/Current:** Exposure to soil at CAX-IRP sites or AOCs would not cause adverse health effects because the contaminant concentrations are below levels of health concern for the exposures that are expected for CAX residents and visitors, or access to the site is restricted to authorized personnel only. Base residents and visitors will not contact site-related contaminants in the soil at levels that could cause health concerns. **Future:** If land use patterns change or additional disposal areas or contaminant levels are identified in the future, ATSDR expects that EPA and VDEQ approved remedial actions will ensure that no exposures that could result in adverse health effects will occur.

Table 1. Evaluation of Potential Exposure Pathways at Cheatham Annex (continued)

Pathway Name	Exposure Pathway Elements					Time of Exposure	Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population		
Surface water and sediment at on-site ponds	Operations and waste management at CAX	Surface water and sediment	Cheatham Pond, Jones Pond, Penniman Lake, and Youth Pond	Dermal contact, incidental ingestion	Recreational users, including anyone wading or boating	Past Current Future	**Past/Current/Future:** Surface water and sediment samples collected from the three on-site ponds and Penniman Lake have contained measurable concentrations of a variety of contaminants, including metals in all four water bodies, polychlorinated biphenyls (PCBs) in Youth Pond and Penniman Lake, and polycyclic aromatic hydrocarbons (PAHs) in Penniman Lake. Very low levels of compounds associated with explosives, below levels of health concern, were also measured in all four water bodies. Swimming is and was in the past prohibited. Recreational users could be exposed to surface water and sediment through incidental ingestion of very small quantities of sediment or water. This limited exposure to the relatively low levels of contaminants measured in surface water and sediment is unlikely to cause adverse health effects. People who disregard posted signs and go swimming would also not be exposed to contaminants at levels that could cause health effects.

Table 1. Evaluation of Potential Exposure Pathways at Cheatham Annex (continued)

Pathway Name	Exposure Pathway Elements					Time of Exposure	Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population		
Fish caught in on-site ponds	Operations and waste management at CAX, waste associated with former Penniman Shell Loading Plant	Biota	Cheatham Pond, Jones Pond, Penniman Lake, and Youth Pond	Ingestion	Consumers of fish harvested from on-site ponds	Past Current Future	**Past/Current/Future:** Navy families who live at or who visit CAX to take advantage of its recreational facilities may fish at any of four on-site water bodies described above. Since 2000, fishing at Penniman Lake and Youth Pond has been designated for 'catch and release' only, due to PCBs detected in sediment samples from those ponds. No fish tissue samples have been collected from any of the on-site water bodies. Therefore, it is not possible to identify if past consumption of fish from Penniman Lake or Youth Pond posed a health concern. Surface water and sediment samples from Jones Pond and Cheatham Pond have not identified any contaminants measured at levels that would be expected to pose a concern for people who eat the fish they catch from those ponds. While it is not possible to evaluate the actual exposure people may have had in the past to contaminants that may have been in the fish from Penniman Lake or Youth Pond, it is likely that people did not eat enough fish from either source to cause any health effects. Based on the surface water and sediment sampling results from Cheatham Pond and Jones Pond, health effects are not expected for people who did, or do, consume fish from those areas.

Table 1. Evaluation of Potential Exposure Pathways at Cheatham Annex (continued)

Pathway Name	Exposure Pathway Elements					Time of Exposure	Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Population		
Physical hazards	Operations and waste management at CAX, waste associated with the former Penniman Shell Loading Plant	Physical hazards, such as needles, partially buried objects, waste washed downgradient of disposal sites, and waste associated with shell loading	Areas used to bury or destroy unneeded materials, and the down-gradient areas	Physical hazard	Employees, residents, and visitors at CAX and nearby areas	Past Current Future	**Past:** Physical hazards (e.g., syringe needles and buried trash) were present in the past at several locations. Base residents and visitors had limited contact with these materials. Although these materials represented a safety concern for people at the time of any exposures, no injuries were reported to ATSDR. **Current/Future:** Most, but not all, of the waste materials that could be a safety hazard to base residents and visitors has been removed. Buried items from previous Penniman activities still exist near the cabin area. The Navy erected at fence to protect visitors from the steep bank leading to the York River, which also limits contact with the buried materials. Erosion from Hurricane Isabel (in 2003) damaged portions of the fence. The Navy plans to repair the fence. ATSDR recommends that these repairs be made quickly to prevent future hazards. ATSDR expects that EPA and VDEQ supervised investigations and remediation of any areas where physical hazards might be present will be conducted in a manner that will be protective of residents and visitors.

Abbreviations:

AOC	area of concern
ATSDR	Agency for Toxic Substances and Disease Registry
CAX	Cheatham Annex
IRP	Installation Restoration Program
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
TNT	2,4,6-trinitrotoluene
VOC	volatile organic compound

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 1 Landfill Near Incinerator	This landfill was used from 1942 to 1951 as a disposal area for burn residues. There was formerly a nearby incinerator that was dismantled between 1989 and 1992. From 1951 to 1972, Site 1 was a general landfill. An estimated 34,500 tons of solid waste were buried here. Until 1981, waste such as paint and paint thinner cans, cartons of ether, other drugs, railroad ties, tar paper, sawdust, lumber, rags, and concrete were burned and/or disposed of at the site. In 1981, the landfill was closed, and 2 feet (ft) of soil and vegetation were placed over the roughly 1.3-acre site. Surrounding Site 1 are woods and a steep 25-foot drop to the York River. Wave action and lack of vegetation caused erosion and created a natural berm between the site and the river. During storms, runoff from the site flows to the river. The site was only partially fenced until 1997, when a fence with a secured gate was installed around the flat part of the site (including most of the landfill). The Navy will address a disposal area north of Site 1 that contains junk cars and helicopter parts as Area of Concern (AOC) 5.	Landfill waste was buried up to 20 feet below ground surface (bgs). Groundwater samples were collected between 15 and 30 ft bgs. Surface soil and sediment from the nearby marsh contain metals and polycyclic aromatic hydrocarbons (PAHs). Contaminants detected above comparison values (CVs) are shown below, along with their maximum detected concentrations. **Groundwater (parts per billion [ppb]):** Aluminum (21,700), Antimony (232), Arsenic (473), Cadmium (45.7), Chromium (115), Copper (675), Iron (80,800), Lead (2,520), Manganese (4,480), Nickel (329), Thallium (2.1), Vanadium (120), Zinc (37,700), Methylene Chloride (27), Bis(2-ethlyhexyl)phthalate (1,145; the second highest concentration was 72) **Surface Soil (parts per million [ppm]):** Antimony (69.5), Arsenic (31.2), Cadmium (30.5), Copper (4,250), Iron (43,400), Lead (2,720), 4,4'-DDT (2.2), Arochlor 1260 (4.2), Benzo(a)pyrene (94), Benzo(a)anthracene (120), Benzo(b)fluoranthene (120), Benzo(k)fluoranthene (45), Carbazole (36), Chrysene (120), Dibenz(a,h)anthracene (17), Indeno(1,2,3-c,d)pyrene (58), 2-Methylnaphthalene (9.6) **Surface Water (ppb):** Arsenic (14.1) **Shallow Sediment (ppm)** (collected from a depth of 0–4 inches)**:** Arsenic (11.7), Iron (29,800), Arochlor 1260 (0.81), Benzo(a)pyrene (2.4), Benzo(a)anthracene (3.3), Benzo(b)fluoranthene (5.6), Dibenz(a,h)anthracene (0.57), Indeno(1,2,3-c,d)pyrene (2) **Nearby tributary:** According to the Navy, polychlorinated biphenyls (PCBs) are present. However sampling results were not available.	In 1998 a geophysical survey delineated site boundaries. In 1999 and 2000, debris present on the beach area along the northeast perimeter of the site was removed. Sand-filled tubes were installed to stabilize the bank of the York River and to reduce the potential for buried waste to reach the river. The Navy dug test trenches in 2001 to obtain additional information about the landfill. The Navy removed an estimated 20,000 cubic yards of contaminated soil, landfill material, and debris during the summer of 2003. The fence was removed after this occurred. The Navy plans to address potential groundwater and sediment contamination, including contamination in an adjacent wetland, in the future. Remedial actions are ongoing. A draft RI was issued in 2002, but a final RI has not yet been released.	There is no public health hazard from this site. Contaminated soils were removed. The limited amount of public access expected in the wetlands is not at levels of health concern. Prior to the soil removal, access by the public to the soil contaminants was limited by the fence. Contaminated groundwater does not impact local drinking water sources.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 2 Contaminated Food Disposal Area	Site 2 is located in a grassy area of the woods behind a cold storage warehouse. At the time it was initially investigated, the area was overgrown. In 1970, a leak that developed in a cold storage room contaminated approximately 100 cubic yards of frozen food with ammonia. The contaminated frozen food, with cellophane wrappers and boxes intact, was subsequently buried in a pit approximately 50 ft in diameter and 12 to 15 ft deep.	Not Available (N/A)	No corrective activities have been conducted or are planned, as the Navy expects that wastes buried at the site would naturally decompose. The U.S. Environmental Protection Agency (EPA) and the Virginia Department of Environmental Quality (VDEQ) concurred, in September 2003, with the Navy's decision to assign this site No Further Response Action Planned (NFRAP) status.	There is no public health hazard from this site. Public access is prevented by the soil cover and vegetation. Potential groundwater contamination is not expected to impact local drinking water sources.
Site 3 Submarine Dye Disposal Area	Drums containing fluorescein dye were formerly stored in 55-gallon drums on 2 to 3 pallets. Drums were repeatedly stored and removed through the early 1970s. The drums corroded, and sometimes dye leaked into the ground and the storm sewer system. During rain events, puddles containing green dye were observed, and dye leaking into the storm sewer system reportedly sometimes turned the York River green. The submarine dye disposal area is currently used as a storage lot.	N/A	No further action is planned at this site, because the dye released at this site degrades rapidly, and the releases involved a small volume of dye. The Navy, with EPA and VDEQ concurrence, assigned this site NFRAP status in September 2003.	There is no public health hazard from this site. Fluorenscein is a commonly used dye for food, cosmetics, medical procedures, and water transport studies. The infrequent exposures expected to the dye in the soil, runoff, or river water were likely below levels of concern.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 4 Medical Supplies Disposal Area	Site 4 is located along an unnamed pond just upgradient of Youth Pond, but inside the fenced warehouse area of the facility. In 1968 or 1969, apparently unused medical supplies were dumped down a bank and covered with soil. Likely wastes include syringes, empty intravenous bottles, and bits of charred material. As much as 7,000 cubic yards of medical waste may have been disposed. During a 1998 site visit, packages of unused needles wrapped in foil were found in a drainage swale leading to the unnamed pond. Prior to a 1998 removal action by the Navy, syringe needles were reportedly getting stuck in deer's hooves. After heavy rains, syringes were sometimes seen in the unnamed pond, Youth Pond, and the culvert where water from Youth Pond drains to the York River. Nearby is AOC 3, where 1-inch metal bands were disposed of. In 1998, the Navy identified additional medical supplies buried at AOC 4. The Navy will address all of the medical waste together with Site 4. The medical supplies and surface soil overburden at Site 4 are estimated to together comprise a volume of 2,000 cubic yards.	In 1999, 7 surface soil samples and 8 sediment samples were collected and analyzed. The sediment samples were collected at four locations in the upstream pond. Half of the samples were collected at depths of 0 to 4 inches, and the other half were collected at depths of 4 to 8 inches. Contaminants detected at levels above CVs are shown below, along with their maximum detected concentrations. These samples suggested that iron had not migrated from the scrap metal banding pile to sediment, but both soil and sediment samples contained PAHs and PCBs. Storage and parking areas drain to the site, and they may be the source of PCB contamination. **Surface Soil (ppm):** Arsenic (4.1), Iron (67,100), Aroclor-1242 (1), Aroclor-1260 (2.7), Benzo(a)anthracene (8.8), Benzo(a)pyrene (7), Benzo(b)fluoranthene (6.8), Bis(2-ethylhexyl)phthalate (16), Dibenz(a,h)anthracene (1.4), Indeno(1,2,3-cd)pyrene (3.4) **Sediment (ppm):** Arsenic (12.2), Benzo(a)pyrene (0.34)	In 1998, approximately 200 pounds of surface debris and 13 pounds of sharp metal and plastic items were removed from the site and incinerated. Soil and sediment sampling was conducted in 1999. In 2001, test trenches were dug to obtain additional information about the horizontal extent and depth of buried waste, which was found up to 5 feet bgs (the level at which groundwater is encountered). The trenches were then filled. The Navy has recommended that an engineering evaluation/ cost analysis (EE/CA) be completed to assess ways to remediate this site and prevent buried materials from being washed into the upstream pond. The Navy has submitted a draft ecological risk assessment for this site, Site 9, and Site 11.	This area is fenced and access to this is limited to authorized personnel. Contaminant concentrations in the soil at this site are below levels of public health concern for infrequent exposures by potential recreational users of Youth Pond. The presence of syringes, especially needles, and glass bottles does represent a safety hazard. However, ATSDR expects that the EPA and VDEQ approved remedial action will eliminate all concerns at this site and in areas to which waste from this site might be transported.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 5 Photographic Chemicals Disposal Area	Site 5 is reportedly at the south end of Second Street, west of Site 11. In 1967 or 1968, photographic chemicals (developers and fixers) were said to have been disposed of in a "marl pit" at this location. The pit was thought to have received between 20 and 40 gallons (1 pallet) of these types of chemicals. In 1998, the Navy conducted a site visit, but was unable to locate any evidence of contamination.	N/A	No corrective actions have been conducted or are planned because of the small quantity of chemicals reportedly disposed of and the lack of evidence of contamination. This site received NFRAP status in September 2003.	There is no public health hazard from this site. It is located in the industrial area of the base, and contact with this site by past base residents or current visitors is expected to be minimal. Potential exposure to these contaminants is below levels of health concern.
Site 6 Spoiled Food Disposal Area	This spoiled food disposal area is located south of First Street. Around 1970, approximately 750 cubic yards of food that spoiled in cold storage were buried in a 12 to 15 ft deep pit. No connection between this site and Site 2 is discussed in the first document describing potential IRP sites, the initial assessment study (IAS), or in more recent documents available to ATSDR.	N/A	No investigations have been conducted or are planned because the Navy concluded that decomposing food was not hazardous. This site is included among those which were assigned NFRAP status in September 2003.	There is no public health hazard from this site. Public access is prevented by the soil cover. Potential groundwater contamination is not expected to impact local drinking water sources.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 7 Old DuPont Disposal Area	Site 7 is a disposal area reportedly receiving unspecified waste from the City of Penniman and the Penniman Shell Loading Plant. The 1984 IAS states that ammunition waste was disposed of at the site, but gives no details. Specific information on the types and quantities of waste received was not available. The actual location of Site 7 has been difficult to identify. Original records positioned it between two cabins along the York River. Two disposal sites have been identified in this area and will be addressed as Site 7. One site was identified as Site 13 in some documents; both sites are now identified as Site 7. Records indicate the original Site 7 was a disposal area post-dating World War I and also used as a borrow area. There are steep banks on all but the southern side, and there is a berm along the northern perimeter. Debris outcrops on the eastern side. See Site 13 for information specific to that area.	In 1999, 10 test pits were excavated to try to determine where debris was buried. One spent shell (a 75 mm salute round) was found. In two test pits in the northern portion of the site, heavy debris was encountered. Charred fragments were encountered in a third, and piping surrounded by stained soil was encountered at two others. There was fill with occasional trash in the other test pits. **Sediment:** One sample was a collected east of the buried debris, in an area that receives runoff from the site. The sample was analyzed for organics, inorganics, and explosive compounds; only arsenic (20 ppm) and Aroclor 1260 (0.54 ppm) exceeded their CVs.	In 1999, 10 test pits were excavated to try to determine where debris was buried. The pits were backfilled after the investigation. According to the Navy, further investigation and possible removal of sources of contamination may be required, and a future investigation is planned. See Site 13 for information about the effects of Hurricane Isabel (in September 2003) on this disposal area and Site 13.	Contaminant concentrations in the soil at this site are below levels of public health concern for infrequent exposures by recreational users. The presence of certain types of waste material, especially the potential for explosives and ammunition, does represent a safety hazard. At present, a fence that keeps visitors away from the site is damaged. ATSDR recommends that it be fixed promptly. ATSDR expects that the EPA and VDEQ approved remedial action will eliminate future concerns. ATSDR also expects that the environmental investigation and remedial actions will be carried out in a manner that is protective of area visitors.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 8 Landfill Near Building CAD 14	Site 8 is less than ¼ of an acre. The site surface is level and overgrown with tall grasses, with no surficial evidence of waste or stressed vegetation. The former landfill was active at various times between the early 1940s and 1980. It was used most heavily before the landfill at Site 1 was opened and is believed to contain non-hazardous materials (e.g., spoiled meat, spoiled candy, clothing). Specific disposal practices were not documented, but the disposal area is known to have consisted of a series of trenches 2,000 ft long and 10 ft deep.	The IAS concluded that additional study was not needed at this site because the disposed wastes were not hazardous.	No further action is planned at this site because of the inert nature of the materials reportedly buried here (clothing and spoiled food), which are not considered hazardous. NFRAP status was accorded to this site in September 2003.	There is no public health hazard from this site. Access by the public to the waste materials is prevented by the soil cover and vegetation. Groundwater at this site does not impact local drinking water sources. ATSDR expects that the EPA and VDEQ approved remedial actions will eliminate the potential for the landfill to impact the river or Cheatham Pond.
Site 9 Transformer Storage Area	The transformer storage area encompasses approximately 7,000 square ft. It is approximately 1,000 ft from Cheatham Pond. Between 6 and 30 electrical transformers, some containing PCBs, were stored at the site for repair or disposal between 1973 and 1980. The storage was enclosed by an earthen wall, but was not paved. Since 1980, the area has been graded and covered with gravel. No transformers were stored at the site after 1980.	**Surface Soil:** In 13 samples analyzed in 1986 for PCBs and dioxins, all concentrations measured were below CVs.	In 1999, the Navy recommended that no additional sampling be conducted at Site 9 because of the low levels of contaminants detected. However, in 2000, VDEQ and EPA recommended conducting further investigations and an ecological risk assessment. The ecological risk assessment for this site, Site 4, and Site 11 has been drafted.	There is no public health hazard from this site. Concentrations of contaminants detected in the surface soil are below levels of health concern.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 10 Decontamination Agent Disposal Area Near First Street	Site 10 is located south of First Street. Before 1982, an estimated 75 to 100 gallons of decontamination agent (DS-2) were reportedly buried here. It is not known if DS-2 was neutralized prior to disposal. DS-2 is used to remove contamination from equipment exposed to nerve or blister agents. It is comprised of 70% diethylenetriamine, 28% ethylene glycol monomethyl ether, and 2% calcium hydroxide. The actual location and extent of the disposal area is also not known. Some time prior to 1997, concrete slabs were laid on the site. It is now used by reserve troops for field billeting. Surface runoff from the site flows to Kings Creek.	1992 and 1997 samples revealed low levels (beneath CVs) of only a few VOCs in soil and groundwater. Metals were also detected in these media. The contaminants detected at the site do not appear to be associated with the DS-2 that is suspected of being buried there. The following contaminants were detected above their respective CVs; their maximum detected concentrations are shown in parentheses. **Surface Soil (ppm):** Arsenic (8.4), Iron (38,600) **Groundwater (ppb):** Aluminum (8,420), Arsenic (7.9), Chromium (32.6), Iron (19,900), Lead (35.2), Vanadium (31.1)	In December 1985, a magnetometer survey beneath mounds of soil was conducted to try to locate the metallic containers of DS-2, but little iron was detected beneath the mounds. The buried containers have not been located to date. In 1992 and 1997, site investigations were performed, during which soil and groundwater samples were collected. The contaminants detected did not seem to be related to DS-2. Future investigations at the site are not planned. The Navy, EPA, and VDEQ agreed in 2003 that NFRAP status is appropriate for the site.	Contaminant concentrations in the soil and groundwater at this site below levels of public health concern.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 11 Bone Yard	The bone yard is located approximately 250 ft south of Antrim Road, behind the public works facility. It is an estimated 2.7 acre area that is approximately 80% wooded. Between 1940 and 1978, the site was reportedly used for the disposal of oil, asphalt and tar. Numerous barrels of gasoline (15 at the time of the IAS) and at least two 500-gallon above-ground tanks containing oil and/or asphalt were disposed of at this site. Some of these containers are reported to have leaked. Scrap metal, abandoned cars, asphalt, and other debris were also observed at the site in 1984. Ten 5-gallon containers labeled "paraplastic" (a concrete sealant) were also found, as were 60 drums (half of which were empty) and three tanks that contained tar. Unspecified wastes may also have been buried at the site. Until 1997, the above-ground tanks, drums, construction materials, scrap metal, and other debris were present on site. Surface water at Site 11 drains into Penniman Lake via two small drainage ditches.	Soil sampling revealed PAHs, PCBs, selected metals, and explosive compounds (such as TNT), but only metals and PAHs exceeded CVs. Groundwater samples contained a few VOCs (that may have been lab contaminants) at very low concentrations in 1992, but not in 1997. Metals have consistently been detected in groundwater. Contaminants detected above CVs are shown below, along with maximum levels detected. **Surface Soil (ppm):** Arsenic (59.4), Iron (46,600), Lead (1,070), Benzo(a)anthracene (39), Benzo(a)pyrene (39), Benzo(b)fluoranthene (30), Benzo(k)fluoranthene (27), Dibenz(a,h)anthracene (1.4), Indeno(1,2,3-c,d)pyrene (24) **Groundwater (ppb):** Aluminum (21,800), Arsenic (282), Cadmium (3.5), Chromium (71.4), Iron (99,400), Lead (20.8), Manganese (1,110), Thallium (2.2), Vanadium (108), Bis(2-ethlyhexyl)phthalate (49), Methylene chloride (22) **Surface Water (ppb):** ***From Penniman Lake, near Site 11:*** Arsenic (22.7), Thallium (1), Bis(2-ethylhexyl)phthalate (3), Methylene chloride (5), Total phenols (4,000), Trichloroethylene (16) ***From a nearby tributary to the lake:*** Arsenic (2) **Shallow Sediment (ppm):** ***From Penniman Lake:*** Arsenic (12.9), Iron (23,500), Benzo(a)pyrene (0.67), Benzo(a)anthracene (1) ***From a nearby tributary to the lake***: Arsenic (3.3), Benzo(a)pyrene (0.14) ***From the nearby marsh:*** Arsenic (8.3), Iron (26,500), Benzo(a)pyrene (0.18), Benzo(b)fluoranthene (0.37)	Several removal actions have been conducted at this site since 1987. Surface water, sediment, groundwater, soil, soil gas, and drum samples have been collected as part of various site investigations in 1986, 1988, 1992, and 1997. Contaminant levels were lower in 1992 than in 1997. Additional surface water and sediment samples were collected recently, but results are not yet available. The Navy believes that removal actions have eliminated sources of contamination. To further evaluate the site, an RI and feasibility study are planned. A draft RI was scheduled to be submitted in November 2003, but has not yet been released. A draft ecological risk assessment for this site, Site 4, and Site 19 has also been submitted.	Contaminant concentrations in the soil at this site are below levels of public health concern for infrequent exposures by recreational users.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 12 Disposal Site Near Water Tower	Site 12 is approximately 2,000 ft west of Jones Pond. It was used for surface disposal of scrap metal, including auto parts and iron pipe. Approximately 10 to 110 cubic ft of material has been disposed at the site. A historic report notes that a small mound of dark-toned material was present at this site in 1955, but not in 1963. There has been speculation that waste from the site was moved to AOC 2. The part of Navy property near the water treatment plant is fenced, and this site is within the fence. However, Navy personnel and their families using Jones Pond for recreation can reach this site.	N/A	Materials disposed of are reportedly non-hazardous. However, the Navy decided to would conduct limited sampling to assess the impact of past storage activities. A limited field investigation is in progress, along with a report documenting its findings. It was originally scheduled for completion in December 2003, but has not yet been released. According to the Navy, contaminants (including metals) associated with Site 12 are present not far from Jones Pond, as well as along nearby railroad tracks.	Given the location, topography and vegetation at this site, it is unlikely that recreational users would have a significant amount of contact with these waste materials. However insufficient data are available to identify if contaminants are present at levels that could have affected the water quality of Jones Pond, which was used as the base drinking water source until 2002. ATSDR expects that the EPA and VDEQ approved NFRAP or remedial actions will address any health and safety concerns associated with this site.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Site 13 Penniman Disposal Area	This disposal area was originally identified in the 1984 IAS and was named Site 7 at that time. The IAS indicated that it received unspecified waste from the Penniman Shell Loading Plant and the City of Penniman. According to the IAS, wastes were thought to be non-hazardous, but may have included ammunition. The Site 7 disposal area was described as being located between two cabins along the York River. During the 1990s, the Navy did not find a disposal area meeting this description. Instead, the Navy located a nearby disposal area containing waste post-dating the Penniman era and renamed that area Site 7. In 2000, a disposal area fitting the IAS description of Site 7 was discovered. Debris such as melted glass and engine parts dating back to World War I was found between the two cabins and the York River. That site, termed the Penniman Disposal Area, was temporarily designated Site 13. This site is on a steep bank overlooking the York River. The top of the cliff is about 20 feet above the water surface. In the future, Site 13 will be addressed jointly with Site 7 (as a part of Site 7).	N/A	As of 2001, the Navy was planning to investigate contamination at this site. Access to much of the debris at this site had been limited by a fence installed to prevent cabin visitors from getting too close to the cliff. However, Hurricane Isabel (in September 2003) caused significant, visible erosion of this site. The cliff was eroded to the extent that some portions of the fence dangle over eroded sections. In these sections children could crawl under the fence and possibly fall down the cliff, so the dangling fence poses a safety hazard. The Navy plans to repair the fence. Also, the hurricane may have carried some of the waste present in this area or the Site 7 area into the York River; the Navy is evaluating actions to take, given present site conditions. Current Navy plans include repairing the fence.	This site is located near cabins used by on-base vacationers. It is expected that people would have infrequent contact with waste material located between the fence and the cabins. ATSDR expects that the EPA and VDEQ approved remedial action will eliminate this concern. ATSDR recommends that the fence repairs planned by the Navy will be accomplished shortly and expects they will be protective of area visitors.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
AOC 1 Scrap Metal Dump	AOC 1 is a debris disposal area in the southern part of CAX, west of Chapman Road and along unnamed tributaries of Jones Pond. It covers approximately 1.25 acres in 2 ravines approximately 1,000 ft from Jones Pond. There is an extensive amount of wood, metal debris, gas cylinders, steel drums, and construction debris present, some of which protrude from the banks of the ravines. Among the waste observed there in 1998 were drums containing a grease-like substance and a drum that held "black powder," a type of explosive. While the public is kept from the site by locks and a chain-link fence, Navy personnel using Jones Pond for recreation can reach this site.	**Surface Water (ppb):** In 4 samples, arsenic (19), iron (25,900), and bis(2-ethylhexyl)phthalate (98) exceeded CVs. **Surface Soil (ppm):** In 7 samples, arsenic (23.5), iron (35,200), lead (501), benzo(a)pyrene (0.87), benzo(b)fluoranthene (1.7), bis(2-ethylhexyl)phthalate (12), and dibenz(a,h)anthracene (0.35) exceeded CVs. **Sediment (ppm):** The only contaminant detected at concentrations exceeding CVs in 9 sediment samples was arsenic (10.5).	A 1999 site investigation included a geophysical survey and soil, surface water, and sediment sampling. Additional investigation is planned. The Navy also plans to conduct a limited investigation to evaluate disposal options for contaminated media.	Contaminant concentrations in the soil at this site are below levels of public health concern for infrequent exposures by recreational users. The presence of certain types of waste materials may represent a safety hazard. ATSDR expects that the EPA and VDEQ approved remedial action will eliminate this concern.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
AOC 2 Dextrose Dump	This site, identified in late 1997, is in the woods north of Garrison Road, along the southern perimeter of the main portion of CAX. It is near several rows of concrete foundation piers that formerly supported the Penniman Shell Loading Plant Shipping House (demolished between 1918 and 1925). Most buried waste is beneath Deer Pit Road. Investigations conducted through 2001 indicate that the majority of the waste is bottles of dextrose water, with minor debris nearby. There are also separate areas where military clothing, respirator cartridge canisters, and empty 55-gallon drums are buried. A few of the drums had tar residue on them. The metal-plated respirator cartridges were designed for use in the event of chemical warfare. It is estimated that there is less than 1,500 cubic yards of buried waste, in sum. A secured cable running across the road prevents vehicles from accessing this site.	In 1998, soil samples were collected from six borings. Temporary monitoring wells were also installed within four of the borings. The wells drew from the shallowest aquifer encountered (the unconfined Cornwallis Cave aquifer) at depths between 20 and 38 ft bgs. Contaminants detected above their respective CVs are listed below. A tar sample from a buried drum was analyzed for contaminants associated with chemical warfare materials, and none were detected. Most chemicals detected in soil and groundwater samples have been detected at concentrations consistent with what might be naturally occurring **Groundwater (ppb):** Aluminum (189,000), Antimony (13.8), Arsenic (430), Cadmium (8.7), Chromium (595), Iron (380,000), Lead (94.6), Manganese (1,360), Nickel (170), Thallium (2J), Vanadium (417) **Surface Soil (ppm):** Arsenic (20), Iron (44,000)	In 1998, the Navy removed 470 bottles from the site and confirmed that they contained dextrose, as labeled. Geophysical surveys and other field investigations in 1998, 1999, and late 2001 have probed the nature and extent of buried debris. Soil and groundwater samples were collected in 1998. In 1999, six test pits were excavated. An unspecified number of dextrose bottles and 43 empty drums were removed and disposed of off site. Also found were boxes of unopened respirator cartridges. The Navy endeavored to determine their lateral extent, but was not able to remove all the cartridges found because of weather-related constraints. The Navy plans to conduct an EE/CA as part of determining additional actions to take at this site.	Contaminant concentrations in the soil at this site are below levels of public health concern for infrequent exposures by recreational users. The presence of certain types of waste materials may represent a safety hazard. ATSDR expects that the EPA and VDEQ approved remedial action will eliminate this concern.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
AOC 3 CAD 11/12 Pond Bank	AOC 3 is located near Site 4, along the northern bank of an unnamed pond between two buildings known as CAD 11 and 12. It is 20 ft by 20 ft wide and includes a 10 ft tall pile of metal banding. There are also a few empty drums present. The area was designated an AOC in 1998.	This AOC is adjacent to Site 4. During the 1999 field investigation of Site 4, one surface soil sample and one shallow sediment sample were collected next to the metal banding pile at this site. Contaminants detected at concentrations exceeding CVs are listed below. **Surface Soil (ppm):** Arsenic (2.7), Iron (61,700), Thallium (35.7), Benzo(a)anthracene (8.8), Benzo(a)pyrene (7), Benzo(b)fluoranthene (6.8), Dibenzo(a,h)anthracene (1.4), Indeno(1,2,3-cd)pyrene (3.4) **Shallow Sediment (ppm):** Arsenic (12.2), Cyanide (15,400), Lead (2,790), Benzo(a)pyrene (0.16)	The Navy is determining what actions to take at this site as part of its evaluation of Site 4; however, this area will be managed separately from Site 4. This site is scheduled for an EE/CA and removal action.	Contaminant concentrations in the soil at this site are below levels of public health concern for infrequent exposures. The presence of the waste material may represent a safety hazard. ATSDR expects that the EPA and VDEQ approved remedial actions will eliminate this concern.
AOC 4 Medical Supplies Disposal Area	The medical supplies disposal area is being addressed inclusively with Site 4, discussed above.	See Site 4 for information about investigation and monitoring results.	No further action is planned at this site. In 1998, AOC 4 was identified. Based on a review of site history and information, the Navy determined that AOC 4 is the same area as Site 4 and will not be addressed as a separate entity.	See Site 4 for information about potential public health hazards.
AOC 5 Debris Area	AOC 5 is a large debris area north of the Site 1 landfill. Debris at the site includes cables, convex boxes, an empty storage tank, automobiles, airplane and boat parts, and other miscellaneous items. AOC 5 is being addressed in conjunction with Site 1, discussed above, and will no longer be addressed as a separate unit from it.	Soil samples collected near this debris area have contained elevated levels of PAHs (such as benzo[a]pyrene at a concentration of 1.2 ppm), Arochlor 1260 (4.2 ppm), DDT (2.2 ppm), and metals, including antimony (59 ppm), arsenic (31.2 ppm), and lead (2720 ppm). Sediment samples have also contained levels of benzo(a)pyrene and arsenic exceeding CVs. See Site 1 for further information about investigation and monitoring results.	A 1998 field investigation of AOC 5 included a geophysical survey, soil sampling, and sediment sampling. The Navy subsequently decided that this site will no longer be managed separately from Site 1.	See Site 1 for information about potential public health hazards.

Table 2. Installation Restoration Program sites and Areas of Concern at Cheatham Annex (continued)

Site	Site Description and Waste Disposal History	Investigation and Monitoring Results	Corrective Activities	Public Health Evaluation
Penniman AOC	The Navy identified five sub-areas where activities during the Penniman era might have caused contamination. See Table 7 for more information.	EPA conducted sampling of the former Penniman Shell Loading Plant in 1999 are presented in Table 7. The Navy has not yet conducted any sampling.	Site investigations for this AOC are planned, but have not yet been scheduled.	Potential Penniman disposal sites have been identified in industrial or heavily vegetated areas. These sites only have a limited opportunity for direct contact with the contaminants. Available environmental sampling results suggest area visitors are not expected to be exposed to contaminants at concentrations that could cause health concern. ATSDR acknowledges that in the future, additional disposal areas or contaminants could be identified, or land use conditions could change. ATSDR expects that EPA and VDEQ approved remedial activities will eliminate potential health concerns. If requested ATSDR can review additional data after it becomes available, if it is likely to modify this health evaluation.

(Notes for Table 2)

Sources: ATSDR 2000a; Baker 1991, 1997, 1999, 2000, 2003; CH2M Hill 2000; CH2M Hill and Baker 1999, 2000b, 2001a, 2001b, 2003b; CH2M Hill, Baker, and CDM 2001, 2002; EPA 2000b; LANTDIV 2003; USGS 2001; VDEQ 2000; Weston 1999a, 1999b

Note: A Background Study Report has also been drafted by the Navy, but a final version has not yet been issued.

Abbreviations:

AOC	Area of Concern
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
ft	feet
N/A	not available
NFRAP	no further remedial action planned
ppb	parts per billion
ppm	parts per million
VDEQ	Virginia Department of Environmental Quality

Table 3. Potential Contaminant Sources in Jones Pond

Possible sources of contamination:

- Approximately 1,000 feet from Jones Pond is Area of Concern (AOC) 1, which contains wood and metal debris, along with some drums. The U.S. Environmental Protection Agency (EPA) reports some waste left there dates to the Penniman era. Soil samples at the AOC have contained metals and polycyclic aromatic hydrocarbons (PAHs). In addition, a few samples from the pond and its tributaries have contained low levels of explosive compounds.

Contaminant	Maximum Detected Concentration	Comparison Value (CV)	Type of CV	Year of Maximum
Surface water, analyzed in 1999 (by EPA) and 2000				
Heptachlor	0.012B ppb *	0.008 ppb	CREG	1999
Thallium	4.5 ppb	0.5 ppb	LTHA	2000
Sediment, analyzed in 1999 (by EPA) and 2000				
Arsenic	5.6 ppm	0.5 ppm	CREG	2000

Note:
* The concentration of heptachlor detected in laboratory or field blanks is not provided in the EPA report.

Abbreviations:

B (data qualifier)	Not detected substantially above the level reported in laboratory or field blanks
ppb	parts per billion
ppm	parts per million

Sources:
CH2M Hill and Baker 2000a, 2001b; Weston 1999b

Table 4. Potential Contaminant Sources in Cheatham Pond

Possible sources of contamination:

- Site 9, which was used for transformer storage before 1980, is approximately 1,000 feet from Cheatham Pond. 1986 sampling did not show polychlorinated biphenyls (PCBs) at levels exceeding health-based comparison values (CVs), but more sampling is planned.

- During the Penniman era, there was a magazine and a shipping area west of Cheatham Pond. East of Cheatham Pond was a 2,4,6-trinitrotoluene (TNT) production area and the former Penniman "D" Plant, where 75-millimeter and 4.7-inch shells were loaded. Among the buildings present were some in which nitrostarch (an explosive material) was dried and stored, dynamite was mixed, and shells were packed. Some of the structures are as close as 40 feet from Cheatham Pond. In 1999, the U.S. Environmental Protection Agency (EPA) collected and analyzed pond samples at selected locations. The few metals and polycyclic aromatic hydrocarbons (PAHs) detected in EPA samples at concentrations exceeding CVs were found at levels similar to those measured in Navy samples. Pesticides were also present in some samples at concentrations below 0.4 ppm. No explosive compounds were detected in the EPA samples at concentrations exceeding CVs.

Contaminant	Maximum Detected Concentration	Comparison Value (CV)	Type of CV	Year of Maximum
Surface water, analyzed in 1999 (by EPA) and 2000				
Arsenic	6 ppb	0.02 ppb	CREG	2000
Lead	15.7 ppb	15 ppb (action level)	EPA AL	1999
Thallium	4.9 ppb	0.5 ppb	LTHA	2000
RDX	0.44B ppb *	0.3 ppb	CREG	2000
Sediment, analyzed in 1999 (by EPA) and 2000				
Arsenic	75.2 ppm	0.5 ppm	CREG	2000
Iron	35,800 ppm	23,000 ppm	RBC-N	2000
Thallium	6.5 ppm (the other 7 samples did not contain detectable levels of thallium)	4 ppm	c-RMEG	2000

Note:
* Two of five surface water blanks (collected for quality assurance and quality control purposes) analyzed as part of the 2000 Pond Study contained RDX. The detected concentrations were 0.17 ppb in a stainless steel spoon and 0.21 ppb in pump tubing.

Abbreviations:
B (data qualifier) Result is qualified as non-detected at the reported value due to blank contamination
ppb parts per billion
ppm parts per million

Sources:
CH2M Hill and Baker 2000a; Weston 1999a

Table 5. Potential Contaminant Sources in Youth Pond

Possible sources of contamination:

- Immediately upgradient of Youth Pond is an unnamed pond, referred to by the Navy as the upstream pond. The two ponds are separated by a fence. Site 4, the Medical Supplies Disposal Area, is along the upstream pond and within the industrial part of Cheatham Annex. Medical supplies dumped there were reportedly unused. A removal action occurred in 1998. Beforehand, after heavy rains, syringes were sometimes washed into Youth Pond. Soil and sediment samples collected in 1999 from Site 4 and the upstream pond contained primarily metals, Aroclor 1260 (a polychlorinated biphenyl [PCB]), and polycyclic aromatic hydrocarbons (PAHs). Some of this contamination may have come from nearby storage and parking areas.

- Area of Concern (AOC) 3, where there is a pile of metal banding that is approximately 10 feet high, along with some drums, may have affected the pond. AOC 3 is located along the upstream pond, slightly west of Site 1. Soil and sediment samples collected near AOC 3 contained a few metals and PAHs, but results suggested that iron had not leached out of the banding.

- Historical engineering drawings indicate that shell loading activities were conducted within approximately 200 feet of Youth Pond, and that may account for the trace levels of explosives present.

Contaminant	Maximum Detected Concentration	Comparison Value (CV)	Type of CV	Year of Maximum
Surface water, analyzed in 2000				
Thallium	4.2 ppb	0.5 ppb	LTHA	2000
Sediment, analyzed in 2000				
Arsenic	56.2 ppm	0.5 ppm	CREG	2000
Iron	34,800 ppm	23,000 ppm	RBC-N	2000
Aroclor 1260	6.4L ppm	0.32 ppm	RBC-C	2000
Dieldrin	0.086K ppm	0.04 ppm	CREG	2000

Abbreviations:
K (data qualifier) Reported value is biased high
L (data qualifier) Reported value is biased low
ppb parts per billion
ppm parts per million

Source:
CH2M Hill and Baker 2000a

Table 6. Potential Contaminant Sources in Penniman Lake

Possible sources of contamination: • A tributary to Penniman Lake runs through Site 11, used as a disposal area from 1940 to 1978. Items left there included barrels of gasoline, above-ground tanks holding oil and asphalt, and drums, some of which reportedly leaked. Also present were scrap metal, abandoned cars, construction materials, and tar. Removal actions were conducted in 1987 and 1997. Runoff drains into Penniman Lake via two small drainage ditches. Samples were collected in 1986, 1988, 1992, and 1997. Soil samples contained polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), selected metals, and explosive compounds, but only metals and PAHs exceeded health-based comparison values (CVs). Groundwater samples contained metals and a few volatile organic compounds (VOCs) at levels above CVs. In 1992, surface water and sediment samples from a tributary to the lake contained arsenic and PAHs. • Recent sampling revealed PCBs in a drainage ditch leading to the lake from public works buildings. • Area of Concern (AOC) 2 is located near Garrison Road. In this area, runoff and groundwater may flow to Kings Creek or Hipps Pond (within the Fuel Farm), rather than Penniman Lake. At AOC 2, bottles of dextrose, military clothing, respirator cartridge canisters, and empty drums were buried. The respirator cartridge canisters were metal. • The Penniman "G" Plant was located south of Sanda Road and within Garrison Road. Shells of three different sizes were loaded there. Nearby were storage buildings, including a bunker for storing 2,4,6-trinitrotoluene (TNT) and tetryl, as well as an underground mixing tank, the use of which is unknown. Also present at the "G" Plant area were ammonia evaporating and finishing buildings (the foundations of which still remain), a TNT graining house (approximately 25 feet from Penniman Lake), and a TNT catch box (believed to have been used to try to separate TNT particles from waste water, which was then discharged to Penniman Lake). The U.S. Environmental Protection Agency (EPA) sampled these three areas. In the first area, arsenic levels in soil and/or sediment (up to 6 ppm) exceeded CVs. At the graining house sump, levels of arsenic, iron, lead, and TNT (15.5, 101,000, 7,750, and 28 ppm, respectively) exceeded CVs. The sample from the TNT catch box contained arsenic, lead, and TNT at levels (11, 813, and 620 ppm) above CVs.

Table 6. Potential Contaminant Sources in Penniman Lake (continued)

Contaminant	Maximum Detected Concentration	Comparison Value (CV)	Type of CV	Year of Maximum
Surface water, analyzed in 1986, 1987, 1992, 1999 (by EPA), and 2000				
Methylene chloride	861 ppb (the second highest was 21 ppb)	5 ppb	CREG	1986
Trichloroethylene	16 ppb	5 ppb	MCL	1992
Bis (2-ethylhexyl) phthalate	103 ppb (the second highest was 34 ppb)	3 ppb	CREG	1987
Heptachlor	0.01B ppb *	0.008 ppb	CREG	1999
Arsenic	22.7 ppb	0.02 ppb	CREG	1992
Thallium	4.1 ppb	0.5 ppb	LTHA	2000
Sediment (shallow), analyzed in 1986, 1987, 1992, 1999 (by EPA), and 2000				
Benzo(a)anthracene	1 ppm	0.87 ppm	RBC-C	1992
Benzo(a)pyrene	1.9 ppm	0.1 ppm	RBC-C	1992
Aroclor 1260	4.7K ppm	0.32 ppm	RBC-C	2000
Arsenic	40.8 ppm	0.5 ppm	CREG	2000
Iron	69,400 ppm	23,000 ppm	RBC-N	2000

Note:
* The concentration of heptachlor detected in laboratory or field blanks is not provided in the EPA report.

Abbreviations:
B (data qualifier) Not detected substantially above the level reported in laboratory or field blanks
K (data qualifier) Reported value is biased high
ppb parts per billion
ppm parts per million

Sources:
Baker 1997; CH2M Hill and Baker 2000a; Dames & Moore 1986, 1988; Weston 1999b

Table 7. Sites Potentially Impacted by Penniman Activities
(based on U.S. Environmental Protection Agency [EPA] document review conducted in 1999)

Site Name and Status	Site Description	Sampling Results
	Sub-areas of the Penniman Area of Concern (AOC)	
TNT Graining House Sump	The 2,4,6-trinitrotoluene (TNT) graining house sump consists of a concrete-lined pit open at the top and is located 25 feet from Penniman Lake. According to the Navy, TNT was melted or steamed out of packed shells or casings at the TNT graining house. It would have been necessary to separate the TNT from other compounds, to reduce impurities, and that might have been facilitated by the sump and/or the TNT catch box, described below.	TNT was detected at concentrations of 26 and 28 parts per million (ppm) in two soil samples collected by EPA in 1999. These concentrations exceed the ATSDR's comparison values (CVs). A breakdown product of TNT was also detected at a concentration below its CV. The following contaminants, shown with their maximum detected concentrations, were also detected at concentrations exceeding CVs in the two soil samples: arsenic (15.5 ppm), iron (101,000 ppm), lead (7,750 ppm) dieldrin (1.35 ppm), benzo(a)pyrene (55 ppm), chrysene (840 ppm), indeno(1,2,3-cd)pyrene (22.5 ppm), benzo(a)anthracene (126 ppm), benzo(b)fluoranthene (38 ppm), benzo(k)fluoranthene (37 ppm), and dibenz(a,h)anthracene (19 ppm). Further study by the Navy is planned, but on hold. *
TNT Catch Box Ruins	The TNT catch box is an earthen, brick-lined depression next to the TNT graining house. It is thought to have been used to separate TNT particles from wastewater, which was then discharged to Penniman Lake.	EPA collected one soil sample in 1999. Metals, polycyclic aromatic hydrocarbons (PAHs), and some nitroaromatics were detected in the sample. TNT was detected in the sample at a concentration of 620 ppm. Two forms of dinitrotoluene were also detected. One—2,4-dinitrotoluene—was measured at concentration (112 ppm) exceeding its CV. The concentration of arsenic was 11 ppm and of lead was 813 ppm. The PAHs detected at levels exceeding CVs and the levels at which they were detected are: benzo(a)anthracene (22 ppm), benzo(b)fluoranthene (3.6 ppm), and benzo(k)fluoranthene (4.5 ppm). Two sediment samples from the location where the wastewater was thought to discharge contained low levels (below CVs) of TNT and its breakdown products, as well as arsenic (up to 2 ppm, exceeding its CV). A surface water sample from this location contained very few contaminants, but arsenic was detected at 4 parts per billion (ppb), which exceeds its drinking water CV. Further study by the Navy is planned, but on hold. *

Table 7. Sites potentially impacted by Penniman activities (continued)

Site Name	Site Description	Sampling Results
Ammonia Settling Pits	Wastewater from an ammonia finishing building was formerly discharged to these earthen pits and then to Penniman Lake, which is approximately 20 feet away.	EPA analyzed a soil sample, collected within a pit, and a nearby sediment sample, collected where runoff from the pits was thought to discharge. Arsenic was present at levels exceeding its CV. It was found at a concentration of 6 ppm in soil and 4.8 ppm in sediment. Further study by the Navy is planned, but on hold.*
1918 Drum Storage Area	A historical photograph from 1918 showed that in approximately this area, wooden barrels and/or 55-gallon drums were stored.	EPA collected two subsurface soil samples from this location. One sample was collected between 12 and 18 inches below ground surface (bgs), and the other was collected at 18 to 24 inches bgs. The levels of arsenic measured were 4.7 and 5.5 ppm. The deeper sample also contained 23,300 ppm iron. No other contaminants, including nitroaromatics, were detected at concentrations exceeding CVs. The Navy, EPA, and Virginia Department of Environmental Quality (VDEQ) are in the process of determining what future actions are warranted.
Waste Slag Material (also known as Slag Area)	Metallic slag is located throughout the shell loading area, predominantly along the railroad tracks, as well as on National Park Service (NPS) property. A NPS employee speculated that the slag was broken out of boilers on locomotives during the time the Penniman plant operated. Currently, much of the slag is reportedly intact and so hard as to be rock-like.	In 1999, EPA analyzed one soil sample. Metals present in the sample at levels exceeding CVs were arsenic (33.4 ppm), iron (256,000 ppm), and lead (2,600 ppm). Also present were antimony, chromium, and manganese. Several PAHs were also present. Those present at concentrations exceeding CVs were benzo(a)anthracene (7.2 ppm), benzo(b)fluoranthene (6.1 ppm), and indeno(1,2,3-cd)pyrene (7.6 ppm). The Navy, EPA, and VDEQ are in the process of determining what future actions are warranted.

Table 7. Sites potentially impacted by Penniman activities (continued)

Site Name	Site Description	Sampling Results
Other sites within CAX identified by EPA as potentially affected by Penniman activities		
Storm Drain Mixer Openings	At this location, there are openings to an underground steel pipe that is 1 foot in diameter running between the TNT graining house and the ammonia evaporating building.	A low level of arsenic (3.5 ppm, which exceeds the CV) was detected in soil at this location.
Underground Mixing Tank	This underground steel tank with mixing paddles is located approximately one-quarter of a mile southwest of the Penniman buildings that are located adjacent to Penniman Lake.	Several metals and PAHs were measured at concentrations exceeding their CVs. They are arsenic (18 ppm), lead (1,720 ppm), benzo(a)pyrene (6.4 ppm), and benzo(a)anthracene (6.5 ppm), benzo(b)flouranthene (12 ppm), dibenz(a,h)anthracece (7.9 ppm), and indeno(1,2,3-cd)pyrene (27 ppm).
Sites on National Park Service (NPS) property potentially affected by Penniman activities		
FM Smoke Drum (also known as FM/FS Smoke Drum)	A drum identified on NPS land, near locations where there had been ammunition magazines during the Penniman era, was suspected to contain or to have contained an agent known as FM that was apparently used by the military to create artificial smoke. Nearby vegetation was dead.	A sample of soil beneath and around the drum contained levels of the following contaminants that were low, but above CVs: two pesticides (aldrin at 0.27 ppm and dieldrin at 0.39 ppm), two PAHs (benzo[a]pyrene at 2.6 ppm and benzo[b]fluoranthene at 3 ppm), and arsenic (3.5 ppm).
Large Blast Holes	EPA identified approximately 100 holes up to six feet deep, with diameters ranging from 10 to 25 feet. The holes were not far from the FM/FS drum. It is speculated that these holes were created during quality control testing of packed shells during the time the Penniman plant operated.	Two soil samples contained only arsenic (at 12 ppm) and iron (at 46,700 ppm) at concentrations exceeding CVs.
Nitro-Starch Dry House Sumps	Eight brick-lined sump pits are present in eight of the 24 bunkers dating back to the Penniman era that are on NPS property.	Samples from the sump, a nearby drainage way, and a nearby wetlands area did not contain any contaminants at concentrations exceeding CVs.

Notes:

Bis(2-ethylhexyl)phthalate was also measured in soil samples from most of these locations. Reported concentrations ranged from 130 ppm to 260 ppm, which exceed the CV. All the samples in which the compound was measured were marked with a data qualifier (B) indicating that the compound was not detected at a level substantially above the level reported in laboratory or field blanks. In other words, bis(2-ethylhexyl)phthalate may have been a lab or field contaminant.

* The Navy had proposed collecting soil, surface water, sediment, and groundwater samples in three areas that are part of the Penniman AOC. While sampling is planned, it is on hold and has not yet been scheduled.

Sources:
Weston 1999a, b; J. Harlow, U.S. Navy, personal communication, 2003 November 5

Abbreviations:

AOC	area of concern
bgs	below ground surface
CV	comparison value
EPA	U.S. Environmental Protection Agency
NPS	National Park Service
ppm	parts per million
ppb	parts per billion
TNT	2,4,6-trinitrotoluene

Appendix C — ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

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Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Ambient
Surrounding (for example, ambient air).

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Brownfields site
Abandoned, idled or under-used real property where expansion or redevelopment is complicated by real or perceived contamination.

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health

activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

Lowest-observed adverse effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

mg/kg
Milligram per kilogram.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

Nitroaromatic
A type of contaminant associated with explosives, such as TNT.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed adverse effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

ppb
Parts per billion.

ppm
Parts per million.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Substance
A chemical.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compound (VOC)
An organic compound that evaporates readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:

Environmental Protection Agency
(http://www.epa.gov/OCEPAterms/)

National Center for Environmental Health (CDC)
(http://www.cdc.gov/nceh/dls/report/glossary.htm)

National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

For more information on the work of ATSDR, please contact:

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Atlanta, GA 30333
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Appendix D — Comparison Values

ATSDR health assessors use comparison values (CVs) as screening tools to evaluate environmental data that are relevant to the exposure pathways. CVs represent media-specific contaminant concentrations that are much lower than exposure concentrations observed to cause adverse health effects. In that way, CVs are protective of public health in essentially all exposure situations. If the concentrations in the exposure medium are less than the CV, the exposures are not of health concern and no further analysis of the pathway is required. However, while concentrations below the CV are not expected to lead to any observable health effect, it should not be inferred that a concentration greater than the CV will necessarily lead to adverse effects. Depending on site-specific environmental exposure factors (for example, duration of exposure) and activities of people that result in exposure (time spent in area of contamination), exposure to levels above the CV may or may not lead to a health effect. Therefore, ATSDR's CVs are not used to predict the occurrence of adverse health effects. Rather, they are used by ATSDR to select contaminants for further evaluation to determine the possibility of adverse health effects.

CVs used in this PHA include:

Cancer Risk Evaluation Guide (CREG)
Estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed over a 70-year life span. ATSDR's CREGs are calculated from EPA's cancer slope factors (CSFs).

Environmental Media Evaluation Guide (EMEG)
EMEGs are based on ATSDR minimal risk levels (MRLs) and factor in body weight and ingestion rates. An EMEG is an estimate of daily human exposure to a chemical (in mg/kg/day) that is likely to be without noncarcinogenic health effects over a specified duration of exposure to include for acute ($\leq$ 14 days), intermediate (15-364 days), and chronic ($\geq$ 365 days) exposures.

Reference Media Evaluation Guides (RMEG)
ATSDR derives RMEGs from EPA's oral reference doses (RfDs). The RMEG represents the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

EPA's Region III Risk-Based Concentration (RBC)
The U.S. Environmental Protection Agency (EPA) combines RfDs and CSF with "standard" exposure scenarios to calculate risk-based concentrations (RBCs), which are chemical concentrations corresponding to fixed levels of risk (i.e., a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration) in water, air, fish tissue, and soil.

EPA Maximum Contaminant Level (MCL)
The MCL is the drinking water standard established by the EPA. It is the maximum permissible level of a contaminant in water that is delivered to a free-flowing outlet.

MCLs are considered protective of human health over a lifetime (70 years) for individuals consuming 2 liters of water per day.

CVs are derived from available health guidelines, such as ATSDR's MRLs, EPA's RfDs, and EPA's CSFs. These guidelines are based on the no-observed adverse effect levels (NOAEL), lowest-observed adverse effect levels (LOAELs), or the cancer effect levels (CELs) reported for a contaminant in the toxicologic literature. A description of these terms is provided:

Minimal Risk Levels (MRL)
MRLs are estimates of daily human exposure to a chemical (i.e., doses expressed in mg/kg/day) that are unlikely to be associated with any appreciable risk of deleterious noncancer effects over a specified duration of exposure. MRLs are calculated using data from human and animal studies and are reported for acute, intermediate, and chronic exposures.

Reference Dose (RfD)
The RfD is an estimate, with safety factors built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause harm to the person.

Cancer Slope Factor (CSF)
Usually derived from dose-response models and expressed in mg/kg/day, CSFs describe the inherent potency of carcinogens and estimate an upper limit on the likelihood that lifetime exposure to a particular chemical could lead to excess cancer deaths.

Lowest Observed Adverse Effect Level (LOAEL)
The lowest dose of a chemical that produced an adverse effect when it was administered to animals in a toxicity study or following human exposure.

No Observed Adverse Effect Level (NOAEL)
The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

Cancer Effect Level (CEL)
The CEL is the lowest dose of a chemical in a study, or group of studies, that was found to produce increased incidences of cancer (or tumors).

Appendix E — Analysis of Fish Tissue Sampling Data to Identify Potential Public Health Concerns for Recreational and Subsistence Fishers in the Norfolk, VA, Area

Introduction

ATSDR analyzed fish tissue sampling results for fish obtained from a variety of waterways in the vicinity of Norfolk, Virginia. This appendix describes the objectives, methods, and results of the data review.

Purpose

Fishing and fish consumption are both enjoyable pastimes and an important source of nutrition for many people who vacation or live near waterways. The waterways near Norfolk, Virginia, support a variety of fish and are frequented by recreational and possibly subsistence fishers. Some of these waterways are also bordered by military bases, industrial facilities, agricultural areas, roads, parking lots and other potential point and non-point sources of contaminants that could affect water quality and fish tissue contaminant concentrations. ATSDR has performed, or is performing, public health assessments for many of the military installations in the Norfolk area. Frequently, people who live near these installations ask if locally caught fish are safe to eat.

While some installations may be able to provide results of fish tissue sampling for fish obtained from on-base ponds and streams, few installations sample fish from streams or rivers that border the base. ATSDR evaluated fish sampling data obtained from the Virginia Institute of Marine Sciences (VIMS) to identify if public health concerns exist for either recreational or subsistence fishers.

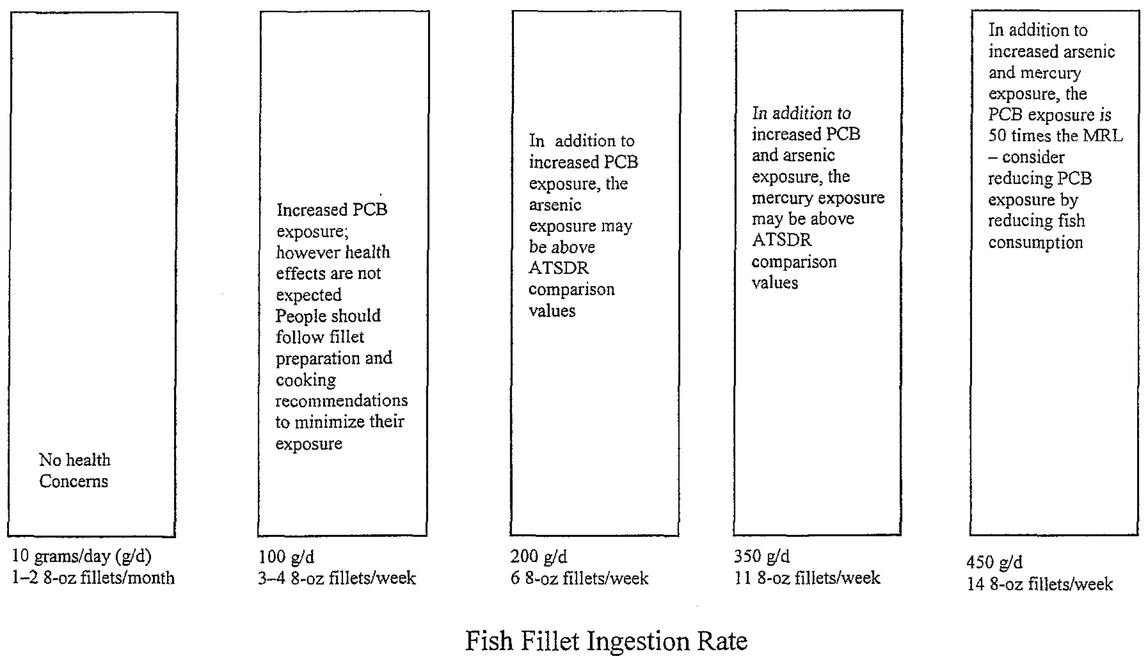
The purpose of this data review was to identify if recreational or subsistence fishers, utilizing the sampled area, could be exposed to contaminants at levels that could cause health effects. This review was not designed to identify potential sources of contamination, describe the impact of neighboring contaminant sources, or evaluate the fate and transport of chemicals detected in the fish tissue. The result of this review is not a definitive analysis of the potential health effects associated with consuming fish from the Norfolk area, but an estimation of the potential health effects associated with consuming fish represented by the sampling data from the sampled locations.

Conclusions

A variety of contaminants were detected in the fish fillet and blue crab samples. The maximum concentration of polychlorinated biphenyls (PCBs), arsenic, lead and mercury detected in some of the fish fillet or blue crab samples were above ATSDR comparison values. A more detailed evaluation considering the entire body of sampling data was completed for those chemicals. Results indicate the concentrations measured in the blue crab are below levels expected to cause health effects. The concentration of PCBs, arsenic, lead and mercury in some of the fish samples were slightly above ATSDR comparison values. However, for all of these chemicals, the concentrations are within the range normally measured in fish and other food groups. Recreational or subsistence fishers who choose to eat fish from other sources or substitute other foods for fish are not expected to significantly change their potential exposure to these chemicals. These chemicals are commonly found in fish and other foods.

The following figure illustrates the health concerns associated with different fish fillet ingestion rates. For the vast majority of fish fillet consumers, there are no health concerns related to fish fillet consumption. People who consume fish several times a week may be exposed to PCB, arsenic and mercury at levels greater than ATSDR's comparison values, however their exposure is not likely to cause health effects. People who routinely consume 2 or more 8-ounce (oz) fish fillets per day will likely have a PCB exposure that is many times greater than the ATSDR comparison value. While this exposure is still below levels known to cause health effects, it would be prudent for those people to consider reducing their fish fillet consumption.

Summary of Health Concerns and Recommendations by Ingestion Rate



Regardless of their fish fillet ingestion rate, fish consumers can reduce their PCB exposure by selecting the younger, smaller fish of a species (within legal limits), removing the skin, belly fat, and internal organs prior to cooking, baking or broiling the fish fillet, and not eating the fatty juices or drippings.

Background

Relationship to other Advisories

Only one fish advisory currently exists for this sample area. The Virginia Department of Health (VDH) issued an advisory for the James River from the Hampton-Norfolk Bridge Tunnel (I-64) near the mouth of the James River, upstream to Richmond. The advisory includes that section of the James River and its tributaries that were originally closed to fishing after sampling identified Kepone contamination in the water, sediment and fish tissue in 1975. Kepone, an insecticide used for ant and roach traps, was released into the river at Hopewell, Virginia, from 1966 until its ban in 1975.

Annual sampling results indicate fish tissue concentrations of Kepone have been decreasing since 1976. Since 1983 the concentrations have been well below the Food and Drug Administration (FDA) action level (Chesapeake Bay Program 1999). Currently there are no fishing bans in this area; however, the Kepone advisory, placed in July 1988, is still in effect. The advisory applies to daily consumption of fish from the James River and tributaries and states that Kepone may be hazardous to your health. There are no specific recommendations or consumption limits (VDH 2003).

The data set reviewed by ATSDR only included information about the chemicals that were detected in at least one of the samples. The data did not include any information about Kepone. This could indicate that it was not considered during the analyses or that all of the fish tissues sampled did not contain detectable levels. Given that some of the fish samples came from the James River near Norfolk and overlapped the Kepone advisory area, it is likely that Kepone was not considered in our data set. Therefore ***ATSDR recommends that fishers of the James River and tributaries continue to be aware of the VDH Kepone advisory.***

VDH has 11 advisories for PCBs in rivers and lakes across Virginia. Recommendations range from limiting consumption of certain fish to not eating any fish from these waters. The closest PCB advisory for the sample area is for the James River and tributaries from the intersection of the Flowerdew Hundred Creek upstream to Richmond. The Flowerdew Hundred Creek is approximately 10 miles upstream from the most upstream James River sampling location. There are no PCB advisories for any of the rivers included in the sampling area (VDH 2003).

VDH considers issuing fish advisories when sampling results supplied by the Virginia Department of Environmental Quality indicate the concentration of PCB congeners in fish fillets may exceed 600 micrograms/kilogram (μg/kg) (or 600 parts per billion [ppb]). This concentration is expected to be protective of the general population (Tripathi 2003). The general population typically includes the non-fishers, recreational fishers, and subsistence fishers in the area surrounding the water body under consideration. Studies indicate the average daily ingestion rate for the general population is approximately 6 to 21 grams/day (g/d), while studies of recreational and subsistence fishers indicate their ingestion rates vary between 17 and 540 g/d (EPA 2000). ATSDR evaluated the VIMS data set to identify if recreational or subsistence fishers primarily using the surface waters within the sampling area would be exposed to contaminant concentrations that would be expected to cause health effects.

VIMS Data

Results of fish tissue analyses for chemical concentrations in fillets were obtained from the Virginia Institute of Marine Science (VIMS). VIMS analyzed a substantial number of fish and shellfish samples provided to them by the Virginia Department of Environmental Quality under a fish tissue monitoring program. VIMS performed the laboratory analysis of the tissue samples and compiled a searchable database. ATSDR obtained results from the database in 2001.

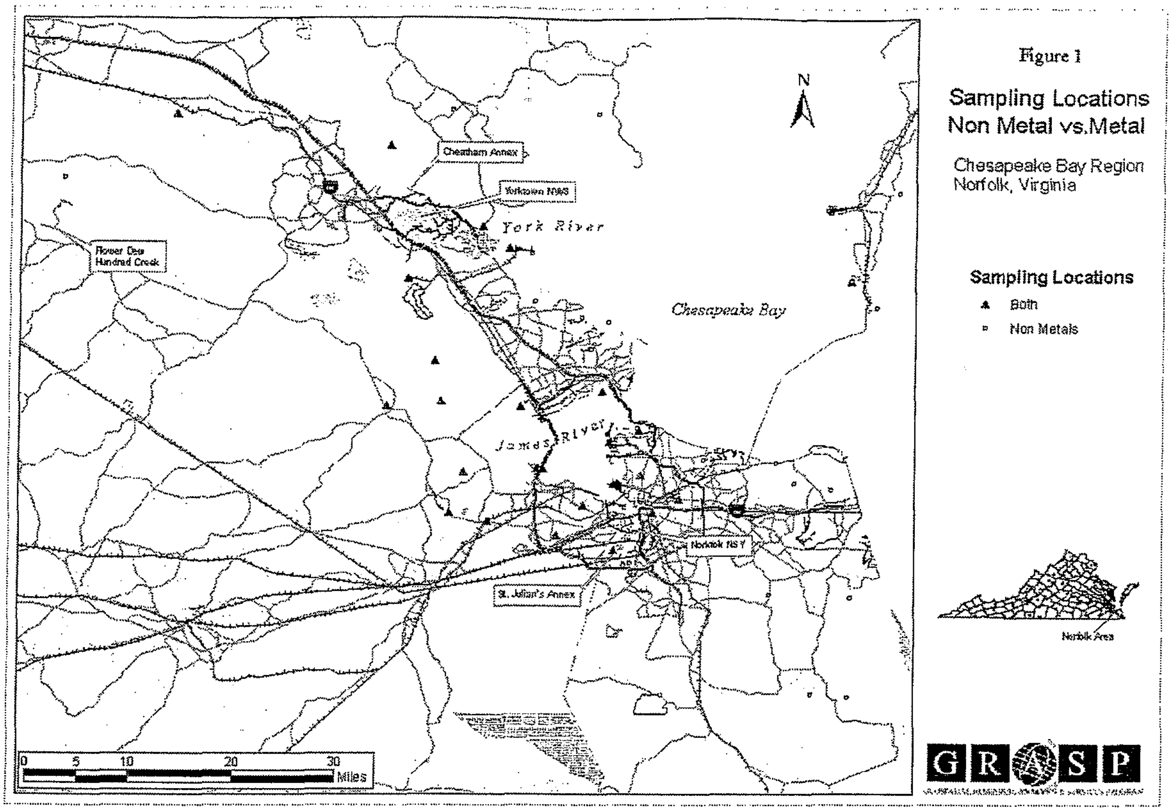
Data description

Figure 1 shows the locations of available fish tissue sampling data, by chemical category. Results were provided for two chemical categories, metals and organics. Metals results included arsenic, cadmium, chromium, lead, mercury and selenium. Organics included pesticides, PCBs and polyaromatic hydrocarbons (PAHs).

Wet weight concentrations were measured in the fillet portion of finfish and the edible portion of blue crab, oyster and clam samples. Typically fillets from similarly sized fish of the same species and from the same sampling location were first homogenized and then chemically analyzed. Samples of blue crab, oysters, and clams only included the 'edible portion' of muscle tissue. While there were several results for blue crab there was only one result each for oysters and clams. Following the initial screening, results from the oyster and clam samples were not considered. Results included the sample identification number, sampling location, sampling date, fish species, number of fish included in the homogenate, average size of the fish and chemical concentration. Tables 1 and 2 show the number of result records evaluated by fish species for both the organics and metals and the time periods during which the samples were obtained.

Figure 1 and Tables 2 and 3 illustrate some of the differences between the results for the organics and metal analyses. Approximately 53 locations were sampled for organics and 25 locations were sampled for metals. At all locations where results are available for metals, results are also available for organics. Not all locations where samples were analyzed for organics were sampled for metals. Twenty seven (27) fish species were analyzed for organics, 20 were analyzed for metals. Again all of the species that were analyzed for metals were also analyzed for organics. Results from the organics sampling were gathered over a 4-year period, while the metal results were only available for the two most recent years. Over 11,000 results are available from the organic analyses while 672 are available for metals. In addition, the metals results provided information about non-detects while the organics results did not. Information about method detection limits was not provided for the organics. Therefore ATSDR analyzed the two data sets separately, but used a similar methodology for each dataset.

Both the organics and metals datasets contain results of chemical concentrations measured in blue crabs, and results for one oyster and one clam sample. While it is not truly appropriate to combine finfish and shellfish data, ATSDR did so during the initial screening to identify contaminants present in any of the tissues above comparison values. Contaminants that were present above the comparison values were considered in greater detail.



Methodology

The organic and metal results reviewed provide information about the concentration of these chemicals measured in the tissue samples. The goal was to identify if health effects would be expected for people who eat fish fillets and blue crabs represented by the sampled tissues. To accomplish this, ATSDR performed a multi-tiered screening analysis to reduce the total number of records to those that could best reflect the potential public health concerns associated with consumption of local fish within the sampled region.

During the evaluation, ATSDR estimated the amount of each chemical people would ingest while consuming fish. The estimated exposure for each chemical was then compared with screening levels that are known to be protective of human health. Specific information on these 'comparison values' (CVs) exist for a wide variety of chemicals that are commonly found in the environment. However, in the case of PCBs and some other chemicals, direct comparison of the measured chemicals with the CVs was not possible.

Table 1. Number of Result Records by Chemical Category and Fish Species

Species	Number of Records; Organics	Number of Records; Metals
BLACK CRAPPIE	38	6
BLUE CRAB	1636	126
BLUEFISH	386	30
BLUEGILL SUNFISH	164	12
CHANNEL CAT	162	6
COMMON CARP	381	6
CREEKCHUB SUNFISH	17	
CROAKER, ATLANTIC	1708	132
FINFISH, UNDOC.	36	
GIZZARD SHAD	2360	114
GREY TROUT	84	6
LARGE MOUTH BASS	339	12
LONGNOSE GAR	75	
MUMMICHOG	961	24
PUMPKINSEED SUNFISH	39	6
REDBREAST SUNFISH	21	
REDFIN PICKEREL	6	
SEA BASS	54	6
SPOT	1717	102
STRIPED BASS	444	24
SUMMER FLOUNDER	171	18
UNKNOWN	90	6
WARMOUTH SUNFISH	23	
WHITE CATFISH	81	6
WHITE PERCH	415	24
YELLOW PERCH	65	
Total Number of Fish Species	27	20
Total Number of Records	11564	672

The VIMS data set included results for individual PCB congeners, combinations of two or three PCB congeners, combinations of PCB congeners and other chemicals (typically pesticides, pesticide metabolites, or pesticide by-products), and metabolites and by-products of parent pesticides. Many of these individual chemicals, and most of these chemical groups, do not have specific comparison values. When possible, ATSDR combined individual chemicals into a chemical group, which could then be compared with a CV, by summing the individual concentrations of contaminants within the group. The chemical groups were prepared for each of the following chemicals:

a. PCBs
b. Chordane
c. DDT and related metabolites and byproducts

d. Endosulfan
e. Heptachlor
f. Hexachlorocyclohexane

Table 2. Summary of Records by Time Period

	Organics	Metals
1997	**542**	
May 1997	116	
October 1997	426	
1998	**2636**	
May-June 1998	1359	
July 1998	1277	
2000	**2573**	**234**
June 2000	2015	
July-August 2000	558	
2001	**5813**	**438**
June 2001	1045	
July-August 2001	3943	
September 2001	825	

Approximately 2006 (17%) of the organic records were not compared to individual or group CVs. These records included 35 different chemicals, mostly PAHs. Only 7 of these chemicals were detected in more than 100 of the 197 total sampling events.

When available the ATSDR chronic oral minimal risk levels (MRLs) were used as CVs; if those were not available, the intermediate MRLs were used.

During the first tier of the process, the maximum concentration of the individual or chemical group was used to calculate an estimated exposure dose (ED) for each chemical using the following formula:

$$ED = C * IR/BW$$

Where

ED = Exposure Dose [g/kg/d]
C = Concentration [g/kg]; the maximum concentration measured in the tissue
IR = Ingestion Rate [kg/d]; the estimated amount of fish eaten on a daily basis
BW = Body Weight [kg]; the body weight of the individual eating the fish
(assumed to be 70 kg = 155.6 pounds [lbs])

During the initial screening, very high estimates of the daily ingestion rate were used for both the recreational and subsistence fishers. Table 3 shows the range of ingestion rates that have been identified in previous studies and the values used for the initial screening. Recreational fishers were assumed to consume 25 g/d of fish fillets; this is equivalent to one 8-oz fish fillet every 9 days, or about 3 to 4 8-oz fillets every month. Subsistence fishers were assumed to consume 400 g/d of fish fillets, which is approximately 1 to 2 8-oz fish fillets every day.

Table 3. Typical Fish Consumption Rates

Fish Consumer Population	Fish Consumption [g/d]	Fish Consumption [oz/d]	Number of 8-oz Fish Meals
Recreational *	17.5	0.6	~ One meal every 12 days
Subsistence *	142	5	~ One meal every day or two
Native American Subsistence *	390	14	~ Two meals per day
Traditional Native American Subsistence *	540	19.4	~ 2 ½ meals per day
Recreational Comparison Consumption Rate **	***25***	***0.9***	***~ One meal every 9 days***
Subsistence Comparison Consumption Rate **	***400***	***14.4***	***~ 1.8 meals every day***

* Information from: EPA 2000, Table 1-3
** Values used by ATSDR during the initial screen process

Individual chemicals or chemical groups where the exposure dose calculated from the maximum concentration exceeded the comparison value were included in the second tier of the evaluation. The second tier evaluation attempted to consider the entire body of sampling data by repeating the exposure dose estimations using the average concentration. In addition, the second tier evaluation also considered information about how frequently the chemical was measured in fish from other locations and the range of measured concentrations. This information was used to evaluate how the potential chemical exposure of recreational and subsistence fishers would change if they switched to consuming fish from other locations or to eating other types of food.

Results and Discussion

Considering just the maximum concentration measured for each chemical or chemical group, the following chemicals were included in the second tier analysis: heptachlor epoxide, total chlordane, total DDT, total PCBs, arsenic, cadmium, chromium, lead and mercury. Additional review of the data eliminated heptachlor epoxide, total chlordane, and cadmium from further evaluation because in each case only one of the 197 sampling events resulted in an estimated exposure dose that was above the CV, and all of the other sampling results were well below the comparison values. Total DDT was not considered for further evaluation because only 8 of the 189 samples with detectable DDT concentrations (of the 197 tissue samples) resulted in an estimated exposure dose in excess of the CV assuming an ingestion rate of 400 g/d, and none of the calculated doses exceeded the CV when the ingestion rate was assumed to be 25 g/d. In addition the estimated exposure dose considering the average concentration and an ingestion rate of 400 g/d (ED = 0.00012 milligrams [mg]/kg/d) was over 4 times lower than the CV (CV = 0.0005 mg/kg/d).

PCBs, arsenic, lead and mercury were considered in greater detail. Results of the initial screening indicated the potential exposure to these chemicals in the tissue samples was greater than the ATSDR CV. They do not indicate that health effects are likely or that there are health concerns associated with the fish or the waterways bounded by the sampling locations. The initial screening method was designed to be a highly conservative method in order to identify which chemicals should receive the greatest attention during the evaluation. The following sections describe the evaluation process used for each of these chemicals.

PCBs

Polychlorinated biphenyls (PCBs) are a mixture of up to 209 individually chlorinated compounds (known as congeners). As a result of their chemical properties, they are highly persistent in the environment and can easily be taken up by fish. PCBs can accumulate in fish so that fish tissue concentrations can be many times greater than that of the water or sediment. In addition to fish, PCBs may be found in other foods such as meat, eggs, milk, bread and cereal. While some people may be exposed to PCBs in occupations dealing with old electrical devices, most people are exposed to PCBs primarily through their diet. The most common health effects documented during occupational exposure include acne and skin rashes. Some studies show occupation exposure led to changes in blood or urine chemistry that may indicate liver damage. The EPA and the International Agency for Research on Cancer (IARC) have classified PCBs as probable carcinogens.

In this dataset, PCBs were detected in fish fillets in almost all of the sampling events. The vast majority of the measured concentrations were within the range of PCB concentrations measured in fish from remote areas (ATSDR 2000). PCB concentrations in fish from lakes and rivers located in Alaska, Wisconsin and the Sierra Nevadas Mountains, taken between 1992 and 1997, ranged between 0.0013 and 0.46 ppm. PCB concentrations in the Norfolk-area sampling locations ranged from 0.0005 to 0.89 ppm; 96% of the Norfolk samples had a concentration less than 0.46 ppm.

As previously mentioned, the data set evaluated by ATSDR contained only information about the chemicals that were above detection limits in the fish fillets. The detection limits for the organic chemicals were not provided. Results for a total of 197 sampling events were included in the data set. There were 181 PCB detections in this data set. The 16 sampling events that did not report PCB concentrations were not included in the calculations for the mean or 95th percentile PCB concentrations because of uncertainty in the PCB detection limit. Therefore the average and 95th percentile PCB concentrations used in this analysis may be slightly over-estimated.

The fish gathering method used by VIMS is believed to have captured the majority of the fish that were in the sampling location at the time the sampling was conducted. It was not designed to gather just the fish that are known to be desired by recreational or subsistence fishers. Some of the samples with reported PCB concentrations were from fish that are not typically eaten by recreational fishers. Table 4 shows all of the species for which at least one PCB result is available and the species that were considered to be most sought after, and therefore eaten, by

Table 4. Fish Species with at least one PCB Detection

All Species	Species Most Targeted by Recreational Fishers
BLACK CRAPPIE	BLACK CRAPPIE
BLUE CRAB	
BLUEFISH	BLUEFISH
BLUEGILL SUNFISH	BLUEGILL SUNFISH
CHANNEL CAT	CHANNEL CAT
COMMON CARP	COMMON CARP
CREEKCHUB SUNFISH	
CROAKER, ATLANTIC	CROAKER, ATLANTIC
GIZZARD SHAD	
GREY TROUT	GREY TROUT
LARGE MOUTH BASS	LARGE MOUTH BASS
LONGNOSE GAR	LONGNOSE GAR
MUMMICHOG	
PUMPKINSEED SUNFISH	PUMPKINSEED SUNFISH
REDBREAST SUNFISH	REDBREAST SUNFISH
SEA BASS	SEA BASS
SPOT	SPOT
STRIPED BASS	STRIPED BASS
SUMMER FLOUNDER	SUMMER FLOUNDER
WHITE CATFISH	WHITE CATFISH
WHITE PERCH	WHITE PERCH
YELLOW PERCH	YELLOW PERCH

recreational fishers. Blue crabs and oysters were not included as a species eaten by recreational fishers because shellfish are physiologically different from finfish and not all recreational fishers consume shellfish. To be conservative, subsistence fishers were assumed to consume all of the finfish species. Because there was only one sampling event each for oysters and clams, they were not included in this evaluation.

For each of the species, Table 5 shows the number of sampling events with a detectable PCB concentration, as well as the maximum, average and 95th percentile concentrations, standard deviation, and coefficient of variation.

Table 6 shows the maximum, average and 95th percentile concentrations, standard deviation, and coefficient of variation for the species used to evaluate the subsistence and recreational fishers and blue crab consumers.

ATSDR estimated the PCB exposure fish consumers would receive based on the amount of fish they tend to eat on a daily basis. Figures 2 and 3 show how the estimated PCB exposure varies with the PCB concentration and the fish fillet ingestion rate. These graphs indicate that for equivalent ingestion rates, subsistence fishers (people who evenly consume every type of fish available in the river) would be expected to have a higher estimated PCB exposure than recreational fishers (people who preferentially consume the recreational target fish). This is because gizzard shad, a fish species not typically consumed by recreational fishers, had relatively high concentrations of PCBs.

Figures 2 and 3 show the estimated PCB exposure for recreational and subsistence fishers based on their daily ingestions rates and the assumed average concentration of PCB in the fish fillets. The 95^{th} percentile and average concentrations were taken from Table 6. Figure 2 considers daily ingestion rates to 500 g/d while Figure 3 only considers daily ingestion rates of 50 g/d or less. Figure 3 also shows the ATSDR chronic oral MRL for PCBs (0.00002 mg/kg/d). This MRL is for non-cancer health effects. Based on the average PCB concentration measured in the fish fillets, both subsistence and recreational fishers consuming less than a daily average of 10 g of fish fillets per day, would have estimated PCB exposures equal to, or less than, the ATSDR MRL. Subsistence and recreational fishers consuming 100 g/d of fish fillets would have an average estimated PCB exposure approximately 10 times greater than the ATSDR MRL. Individuals consuming 500 g/d of fish fillets would have an average estimated exposure of approximately 50 times the MRL. This indicates that people who consume very large amounts of fish caught from the sampling area will be exposed to PCBs at levels above ATSDR comparison values.

Table 5. Sampling Statistics for PCBs by Species

Species	Number	Maximum [mg/kg]	Average [mg/kg]	95th Percentile [mg/kg]	Standard Deviation [mg/kg]	Coefficient of Variation [%]
BLACK CRAPPIE	1	0.08	0.08	0.08	undefined	undefined
BLUE CRAB	35	0.126	0.05	0.115	0.0453	91
BLUEFISH	5	0.232	0.151	0.216	0.0468	31
BLUEGILL SUNFISH	3	0.0843	0.0572	0.0838	0.0426	74
CHANNEL CAT	2	0.256	0.222	0.253	0.489	22
COMMON CARP	6	0.599	0.17	0.515	0.232	137
CREEKCHUB SUNFISH	1	0.00125	0.00125	0.00125	undefined	undefined
CROAKER, ATLANTIC	22	0.29	0.152	0.238	0.0619	41
GIZZARD SHAD	25	0.887	0.375	0.672	0.196	52
GREY TROUT	1	0.12	0.12	0.12	undefined	undefined
LARGE MOUTH BASS	6	0.181	0.0667	0.164	0.0712	107
LONGNOSE GAR	3	0.00201	0.00149	0.00197	0.00059	40
MUMMICHOG	19	0.272	0.0623	0.26	0.0851	137
PUMPKINSEED SUNFISH	1	0.0846	0.0846	0.0846	undefined	undefined
REDBREAST SUNFISH	1	0.000519	0.000519	0.000519	undefined	undefined
SEA BASS	1	0.0927	0.0927	0.0927	undefined	undefined
SPOT	29	0.468	0.107	0.258	0.107	100
STRIPED BASS	5	0.258	0.213	0.257	0.0436	20
SUMMER FLOUNDER	4	0.0896	0.0479	0.0873	0.0411	86
UNKOWN	2	0.0708	0.0365	0.0674	0.0485	133
WHITE CATFISH	1	0.127	0.127	0.127	undefined	undefined
WHITE PERCH	6	0.213	0.107	0.203	0.08589	80
YELLOW PERCH	1	0.0588	0.0588	0.0588	undefined	undefined

Table 6. Summary Statistics of All Fish Species (Subsistence) and Fish Species Targeted by Recreational Fishers

	Number	Maximum [mg/kg]	Average [mg/kg]	95th Percentile [mg/kg]	Standard Deviation [mg/kg]	Coefficient of Variation [%]
Subsistence Fishers	145	0.887	0.154	0.521	0.158	102
Recreational Fishers	100	0.599	0.118	0.258	0.101	85
Blue Crab	35	0.126	0.05	0.115	0.0468	31

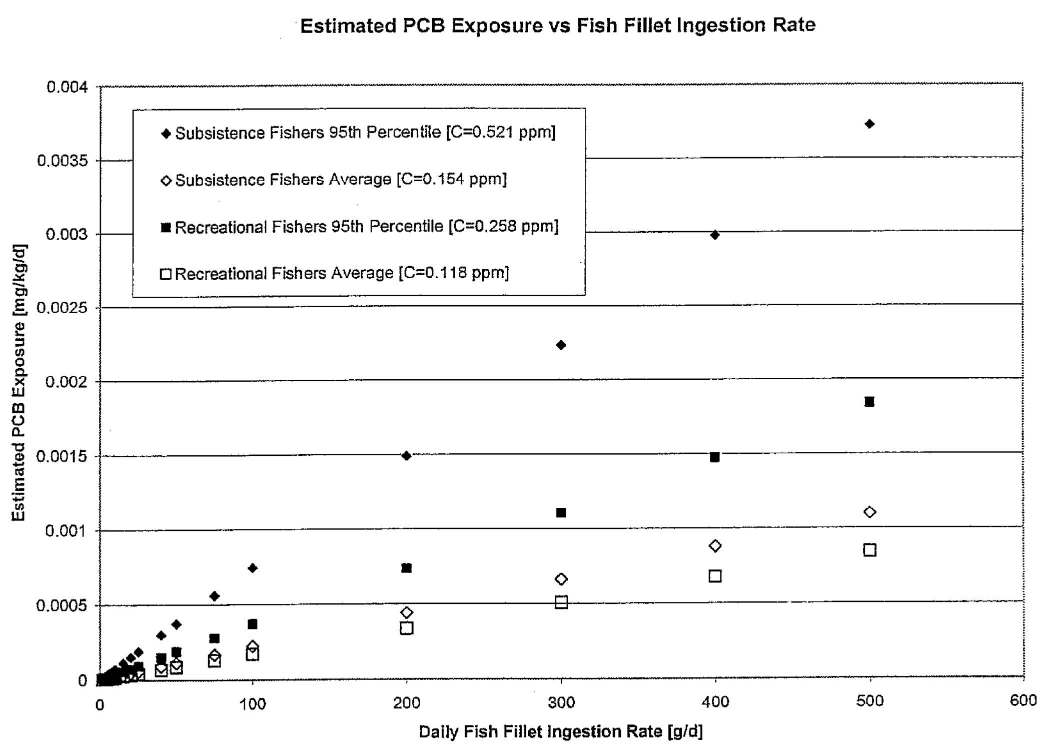


Figure 2

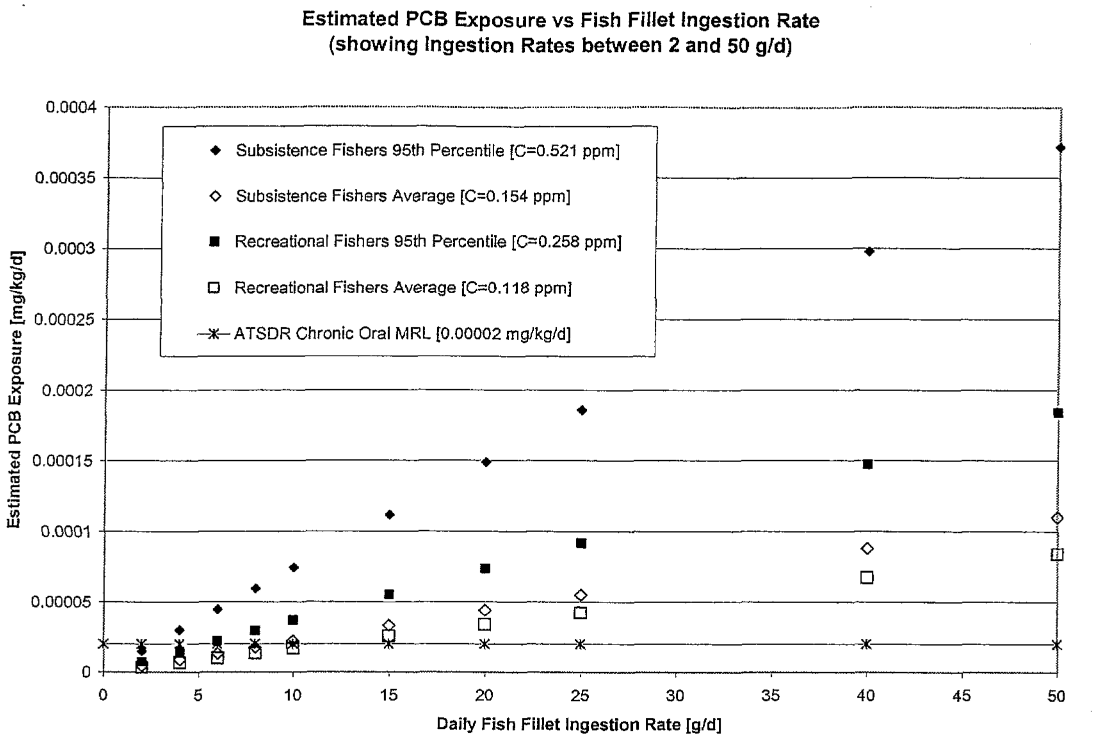


Figure 3

Figures 4 and 5 show how the estimated PCB cancer risk varies with the ingestion rate. These graphs illustrate that the theoretical cancer risk exceeds 10^{-4} for ingestion rates greater than approximately 25 g of fish fillets per day for both subsistence and recreational fishers. These graphs also suggest that people who eat large amounts of fish from the sampling area may be exposed to PCB levels above theoretical risk screening values. Information in the PCB Toxicological Profile (ATSDR 2000) was used to identify if these exposures would be expected to cause health effects.

The PCB Toxicological Profile (ATSDR 2000) briefly summarizes the results of 171 studies conducted using animals that ingested PCBs. Results of these studies suggest that the highest estimated exposure (based on an ingestion rate of 500 g/d, approximately 2.2 8-oz fish fillets per day) is about 10 time less than the exposure shown to cause less serious health effects in some animals. Interestingly, several other studies using higher exposures reported no adverse health effects for similar animal models. In total, the available data is inconclusive about type and severity of health effects that are likely to result following long-term (chronic) exposure to PCBs in fish fillets with concentrations similar to those measured in this sampling area. More moderate consumption rates are several orders of magnitude below these levels.

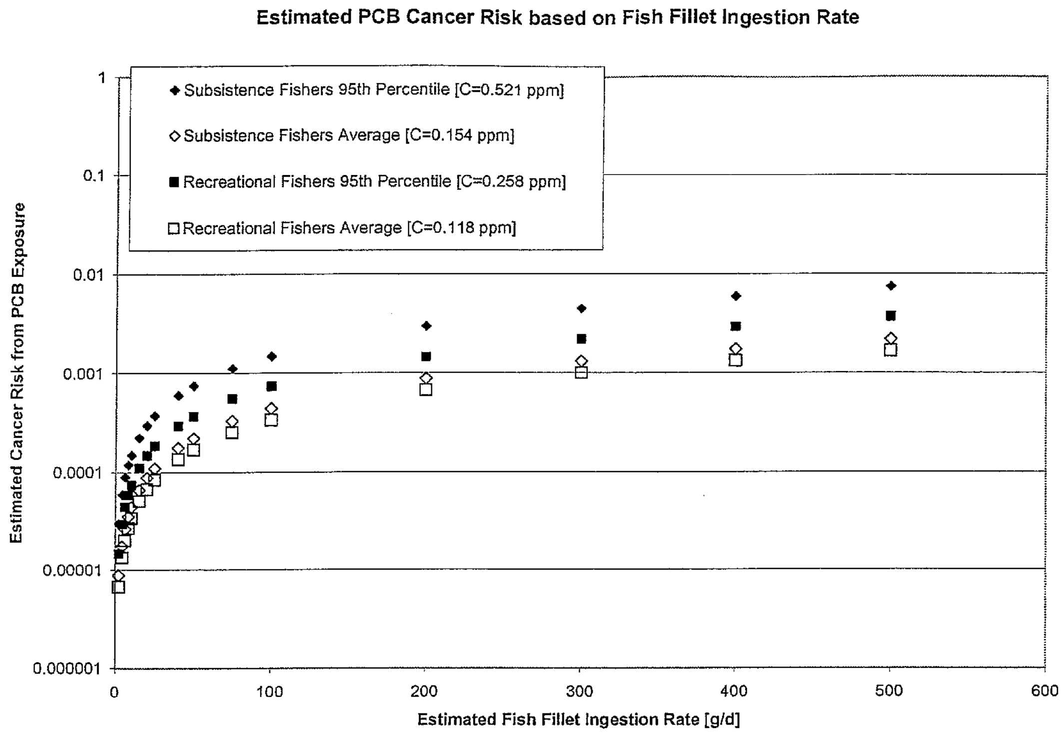


Figure 4

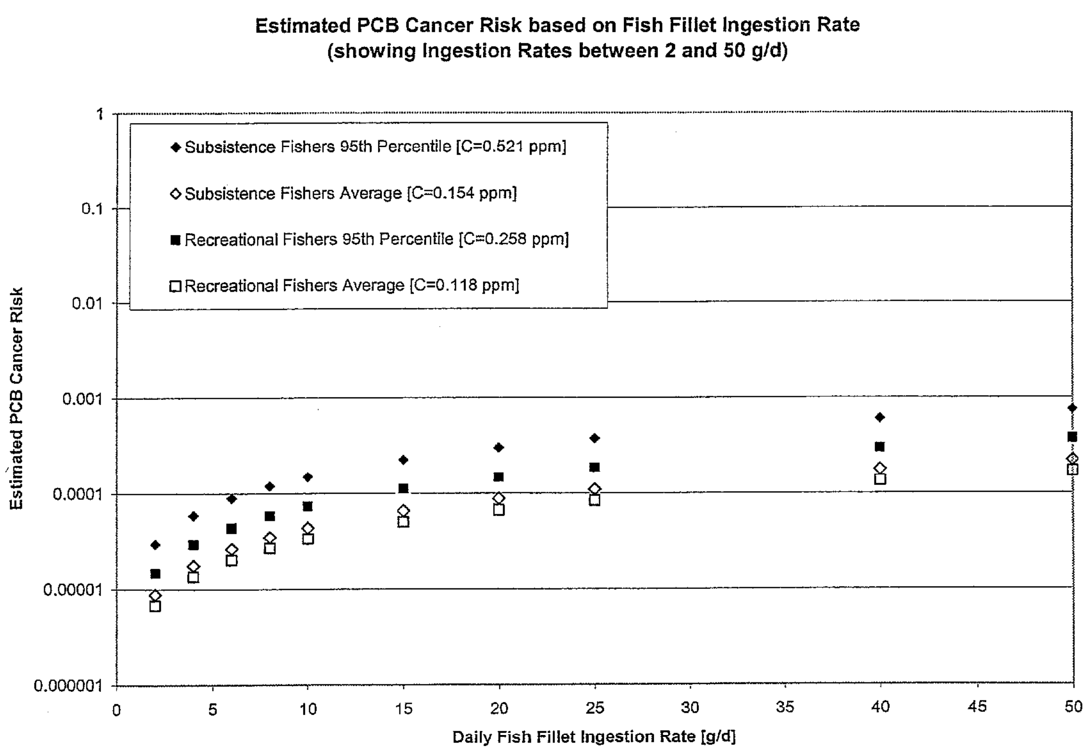


Figure 5

ATSDR expects that people who consume 1 to 2 8-oz fish fillets per month (approximately 10 g/d) will not experience any health concerns. Higher consumption rates, 3 to 4 8-oz fish fillets per week (approximately 100 g/d), are also likely to not cause health concerns. However, people who consume this amount of fish from the sampling area should pay attention to their preparation and cooking methods in order to reduce their PCB exposure. People who consume large amounts of fish from the sampling area, more than 2 8-oz fish fillets per day (approximately 450 g/d), will be exposed to levels of PCBs close to the levels where animal studies first begin to report less serious health effects. While it is uncertain if health effects would be expected in people consuming this amount of PCBs, it would be prudent for these consumers wishing to reduce their PCB exposure to consider supplementing their diet with other protein sources.

However, even if people do not eat the fish from this sampling area, they are still likely to ingest PCBs as a part of their normal diet. The concentration of PCBs measured in the fish from the Norfolk sampling locations is similar to that found in fish from other locations. In addition, the average PCB concentration in these fish is within a factor of 10 of the PCB concentrations measured in other common foods. Table 7 shows the concentration of PCBs measured in other foods. As shown in this table, the major dietary source of PCBs is fish.

The comparison of the fish sampling data from the Norfolk sampling locations with that of fish from other sources (and other foods) suggests that consumption of fish from the Norfolk sampling area is unlikely to cause an increase in PCB exposure for subsistence or recreational fishers, compared to that of other fish consumers around the country. In addition, due to the presence of PCBs in other foods, the exposure of subsistence fishers is expected to be only slightly higher than that of non-fish consumers. Direct health effects of fish consumers due to PCB exposure are unlikely. However people who wish to gain the nutritional value of fish and reduce their PCB exposure may due so by:

1. Selecting the younger, smaller fish of the species (within legal limits)
2. Removing the skin and fatty tissue in the belly and along the sides
3. Baking or broiling the fish
4. Throwing away the fatty juices and drippings
5. Not eating the liver and other internal organs of the fish

These steps reduce PCB exposure because PCBs tend to accumulate in the fat and some internal organs. PCBs are also poorly metabolized; they tend to remain stored in fatty tissue. The younger (and therefore smaller) fish of a species have had less time to accumulate PCBs in their body. Removing the tissues where PCBs tend to accumulate reduces the amount of PCBs ingested by fish consumers. Baking and broiling tend to allow fatty juices, and their associated PCBs, to separate from the fillet.

ATSDR also evaluated the potential for health effects resulting from a large meal of blue crabs based on the average PCB concentration measured in the blue crabs taken from this sampling area. Results indicate that the PCB exposure following a large meal of blue crab would be thousands of times lower than the exposures that have resulted in less serious health effects for animal models. Even meals consisting of 1 to 2 pounds of blue crab would not be expected to cause health effects.

Table 7. Concentrations of PCBs Measured in Food

Food Items Analyzed	Concentration of Total PCBs [ppm]
Maximum of All Fish Samples [1]	0.89
Average of All Fish Samples [1]	0.15
Fillets and Deep Fried Fish [2]	0.55
Fish [3]	0.89
Shellfish [3]	0.06
Standard and Trim Milk [2]	0.01
Milk [3]	0.07
Colby and Mild Cheese [2]	0.24
Cheese [3]	0.01
Ice Cream and Yogurt [2]	0.08
Chicken [2]	0.02
Eggs [2]	0.14
Eggs [3]	0.07
Bread [2]	0.04
Cereal, Rice, Spaghetti [2]	0.07
Potatoes and Hot Chips [2]	0.05
Snack Foods [2]	0.02

1. VIMS dataset described in text.

2. New Zealand Ministry for the Environment, 1998. Concentrations of PCDDs, PCDFs and PCBs in Retail Foods and an Assessment of Dietary Intake for New Zealanders. Organochlorines Programme. November 1998.

3. Duggan et al. 1983, in ATSDR 2000

Arsenic

Arsenic was only detected in 5 of the 112 sampling events, 2 of the 89 fish fillets and 3 of the 21 blue crab sampling events. Table 8 shows the maximum, average and 95th percentile concentrations, standard deviation, and coefficient of variation for the species used to evaluate the subsistence and recreational fishers and blue crab consumers. Since the detection limits were used to estimate the arsenic concentrations in the non-detect sampling events, it is likely that the average concentrations are significantly less than those shown in this table.

Table 8. Summary Statistics for Arsenic Measured in Tissue Samples

	Number *	Maximum [mg/kg]	Average [mg/kg]	95th Percentile [mg/kg]	Standard Deviation [mg/kg]	Coefficient of Variation [%]
All Fish Species	89	1.9	0.525	0.5	0.170	32
Recreational Fishers	66	1.9	0.533	0.5	0.197	37
Blue Crab	21	4.3	0.694	0.64	0.827	119
* Numbers do not include the results from the one oyster and one clam sampling event						

The measured arsenic concentration reports total arsenic; arsenic in fish is typically rapidly converted to a non-toxic organic form. Therefore, the potential health effects associated with fish consumption are typically much less than that predicted by considering the total arsenic concentration. The MRL comparison values used in this evaluation are for the more toxic inorganic forms of arsenic. Studies indicate that between 0.1 – 41% of the total arsenic measured in fish is actually toxic inorganic form of arsenic (ATSDR 2000b). The following evaluation assumed that 20% of the total reported arsenic concentration was present as the more toxic inorganic form. Figures 6 and 7 show the estimated arsenic exposure of fish and blue crab consumers based on the daily ingestion rate and the assumed arsenic concentration.

These graphs illustrates that people who consume up to 200 g/d of fish fillet or 100 g/d of blue crab from the sampling area would not be exposed to concentrations of arsenic above ATSDR comparison values. Because blue crab is only available certain times of the year and some crab enthusiasts are known to eat large portions of crab in one sitting, ATSDR also evaluated the potential arsenic exposure following a large blue crab meal. The previous graph shows both the chronic and acute MRL for arsenic. It shows that a single large meal of blue crab could exceed the ATSDR chronic MRL, it will not exceed the acute MRL. In other words, no adverse health effects would be expected to occur after a single large fish meal. People who consume fish or blue crabs from the sampling area are not expected to develop health concerns.

Arsenic has been identified in a variety of different foods, frequently at concentrations within the range reported for the Norfolk area. Table 9 shows some of the arsenic concentrations reported in various foods. It is expected that fish consumers who choose other sources of fish or foods to replace what they are currently consuming from the Norfolk area will not significantly change their potential arsenic exposure.

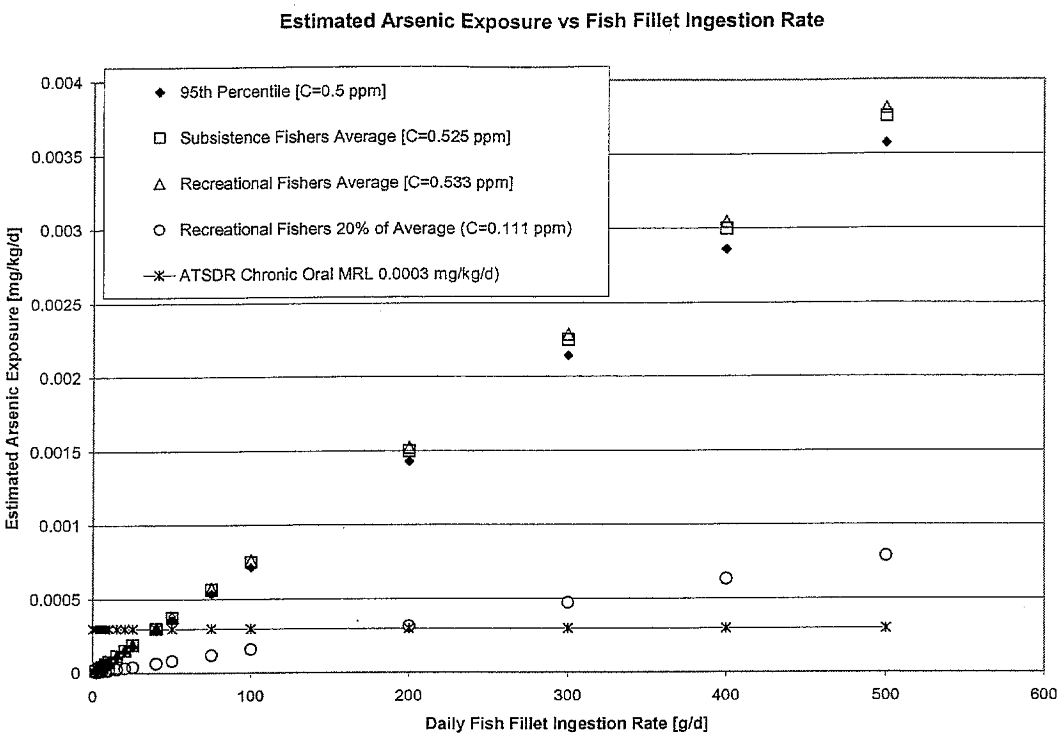


Figure 6

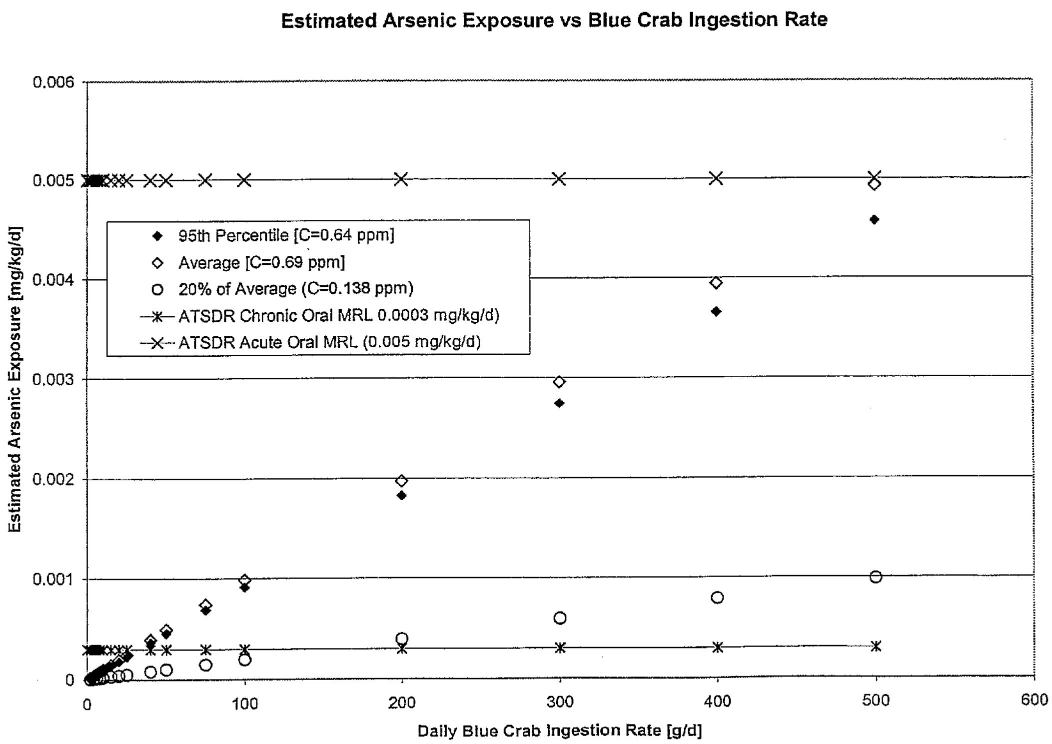


Figure 7

Table 9. Concentration of Arsenic Measured in Food

Food Items Analyzed	Arsenic Concentration [5] [ppm]
Maximum of Blue Crab Samples [1]	4.3
Average of Blue Crab Samples [1]	0.7
Maximum of Fin Fish Samples [1]	1.9
Average of Fin Fish Samples [1]	0.5
Detection Limit for VIMS Fin Fish and Blue Crab Samples [1]	0.5
Fish [2]	1.7
Marine Fish [2]	3.05
Canned Fish [2]	1.2
Meat and Poultry [2]	0.02
Wild Rice [3]	0.006 to 0.1 (Inorganic)
Bakery Goods and Cereal [2,4]	0.02

1. VIMS dataset described in text; total arsenic concentration, as reported.
2. Dabeka et al, 1993, in ATSDR 2000b
3. Nriagu and Lin, 1995, in ATSDR 2000b
4. Garterell et al, 1986, in ATSDR 2000b
5. Value represents the total arsenic unless identified as inorganic

Lead

Lead was only detected in 2 of the 112 sampling events for metals: once in the fish fillets and once in the clam sample. The detection limit was 0.1 mg/kg, the maximum concentration measured was 0.48 mg/kg (fish fillet), and the average concentration across the 112 sampling events was 0.1 mg/kg. There is no MRL comparison value for lead. However, the FDA has published a provisional tolerable total intake level (PTTIL) for lead based on the lowest level of lead exposures associated with adverse effects (FDA 1993). This guidance was used as the basis for ATSDR's evaluation. The greatest public health concern associated with chronic lead exposure is for young and unborn children; premature births, learning difficulties and reduced growth have been associated with lead exposure by pregnant women, infants or young children (ATSDR 1999b). Because of its low solubility, there is little concern about lead-related health effects resulting from eating a large amount of fish or blue crab at one meal (FDA 1993).

Table 10 shows the PTTIL value for various population groups, the assumed body weight for each group, and the resulting calculated number of daily or weekly fish meals an individual from that population group could consume and remain within FDA recommendations. This table indicates that people who consume fish caught within the bounds of the sampling data are not expected to experience health concerns due to lead exposure.

Table 10. Calculated Allowable Number of Daily (Weekly) Fish Fillet or Crab Meals

Population Group	PTTIL [mg/d]	Assumed Body Weight [kg]	ATSDR Calculated Comparison Value [mg/kg/d]	Calculated Allowable Number of Daily (Weekly)* 8-oz Meals Based on the Average Concentration (0.1 mg/kg)
Adults	.075	70 (155 lbs)	0.0011	3.4 (23 – 24)
Pregnant Women	.025	50 (113 lbs)	0.0005	1.1 (7 – 8)
Older Children (7 years or older)	.015	25 (57 lbs)	0.0006	0.66 (4 – 5)
Young Children (6 years or younger)	.006	10 (23 lbs)	0.0006	0.26 (1 – 2)

The average concentration of lead measured in fish fillets was 0.1 mg/kg.
All population groups were assumed to eat meals including 8-oz fish fillets. People who consume smaller fish fillets may consume fish more frequently.
* Values in this column show the number of daily meals with the number of weekly meals shown in parentheses

While reviewing this table, it is important to remember two points. First, these estimates assume that the only lead exposure people have would be from the fish. People who are exposed to lead occupationally or live in older homes (where there might be lead in the water pipes or paint) may want to reduce their total lead exposure by limiting the amount of fish they consume. Second, 110 of the 112 samples had non-detectable lead concentrations; the actual lead concentration was less than 0.1 mg/kg. While it is likely that the lead exposure is less than estimated, it is not possible to know how much less.

Lead has been detected in other foods. Table 11 shows the range of typical concentrations detected in common foods compared to those measured in the fish fillets from the Norfolk area (ATSDR 1999). While the maximum lead concentration measured in the fish fillets is clearly above the typical range, the detection limit is within the range for meat, fish and poultry. So while the detection limit is not low enough to estimate the potential exposure subsistence fishers may have to lead in fish caught in this area, it is expected that people who choose other sources of fish or protein will not significantly change their potential lead exposure.

Table 11. Summary of the Lead Concentration in Other Foods

Food Group	Lead Concentration [mg/kg]
Maximum concentration measured in fish fillet samples [1]	0.48
Detection limit for fish fillet and blue crab samples [1]	0.1
Meat, fish and poultry [2]	0.002 – 0.159
Dairy products [2]	0.003 – 0.083
Grain and cereal products [2]	0.002 – 0.136
Vegetables, fruit and fruit juices [2]	0.005 – 0.649

1. VIMS dataset
2. ATSDR, 1999, page 403

Mercury

In the environment mercury can exist in several different forms; methyl mercury is the form usually found in fish (ATSDR 1994). Mercury was detected in 40 (36%) of the 112 sampling events for metals; 29 of the 89 (33%) fish fillet samples and 11 of the 21 (52%) blue crab samples. Table 12 shows the maximum and average mercury concentration for the fish fillet and blue crab samples, as well as the concentration of mercury reported in other fish. Mercury is commonly detected in fish. It tends to accumulate in fish tissue so that older fish and fish that feed on other fish have higher mercury concentrations. Mercury concentrations are generally low in other types of food; the average concentrations measured in fruits, vegetables, grains, beef, cow milk, poultry and eggs ranged from 0.001 to 0.05 mg/kg. The following table shows the ranges of mercury measured in fish from a variety of environments. This comparison indicates that the concentration of mercury in the fish fillets from the Norfolk area is within the range measured for other lakes and rivers. People who choose to eat fish from other sources are not expected to significantly change their potential exposure to mercury.

The FDA limits the concentration of methyl mercury in fish commercially sold to the public to 1 mg/kg or less. FDA based that limit on studies of people exposed to high levels of mercury. However, there is still some concern whether that limit will protect unborn children from health effects potentially associated with maternal consumption of methyl mercury (FDA 1994). In all of the 112 sampling events, measured concentrations were significantly less than the FDA limit. Figure 8 shows the estimated mercury exposure for fish fillet and blue crab consumers based on their ingestion rate.

This graph indicates that people can consume approximately 325 g/d of fish fillets and 500 g/d of blue crab and remain within ATSDR comparison values. This is equivalent to about 1.4 8-oz fish fillets per day, or more than 1 lb of blue crab per day.

Table 12. Average and Maximum Mercury Concentration Measured in VIMS Samples and in other Locations

Sample Information	Mercury Concentration [mg/kg]
Maximum concentration measured in fish fillet samples [1]	0.17
Average concentration measured in fish fillet samples [1]	0.026
Maximum concentration measured in blue crab samples [1]	0.04
Average concentration measured in blue crab samples [1]	0.017
Detection limit for all samples [1]	0.01
National Contaminant Biomonitoring Program (1984 – 1985) [2]	0.10
Lake Ontario Trout 1977 [2]	0.24
Lake Ontario Trout 1988 [2]	0.12
Fish from the Savannah River [2]	0.10 – 0.72
Canned tuna	0.10 – 0.75

1. VIMS dataset
2. ATSDR, 1994, page 229 -231

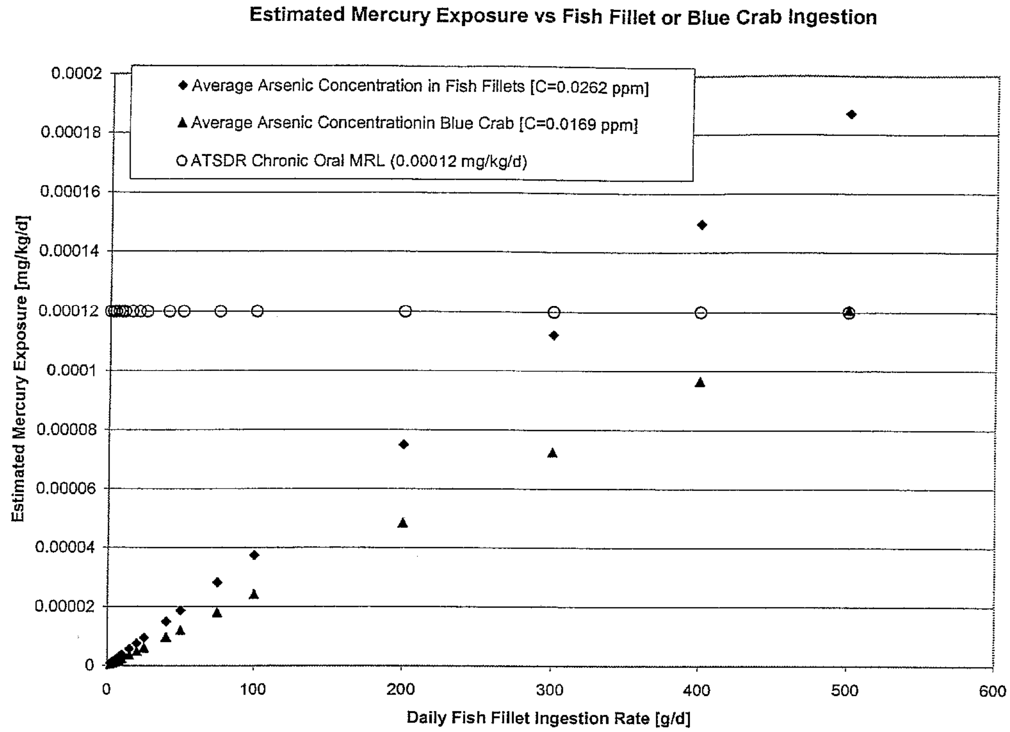


Figure 8

Conclusions

A variety of contaminants were detected in the fish fillet and blue crab samples. The maximum concentration of PCBs, arsenic, lead and mercury detected in some of the fish fillet or blue crab samples were above available comparison values. A more detailed evaluation considering the entire body of sampling data was completed. Results indicate the concentrations measured in the blue crab are below levels expected to cause health effects. While the concentration of PCBs, arsenic, lead and mercury in some of the fish samples were slightly above ATSDR comparison values, the concentrations are within the range normally measured in fish and other food groups. Recreational or subsistence fishers who choose to eat fish from other sources or substitute other foods for fish, are not expected to significantly change their potential exposure to these potential contaminants, because they are commonly found in fish and other foods.

Figure 9 illustrates the health concerns by the fish fillet ingestion rate. For the vast majority of fish fillet consumers there are no health concerns related to fish fillet consumption. People who consume fish several times a week may be exposed to PCBs, arsenic and mercury at levels greater than ATSDR's comparison values, but the exposure is not likely to cause health effects. People who routinely consume 2 or more 8-oz fish fillets per day will likely be exposed to PCBs as levels many times greater than the ATSDR comparison value. While this exposure is still below levels known to cause health effects, it would be prudent for those people to consider reducing their fish fillet consumption.

Summary of Health Concerns and Recommendations by Ingestion Rate

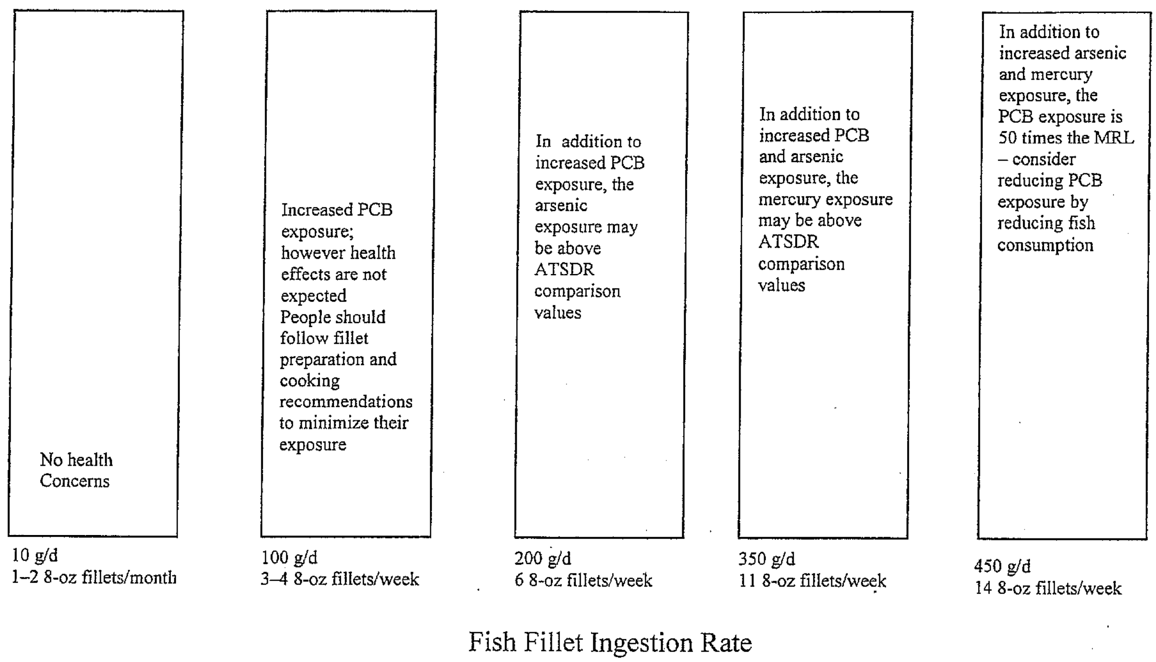


Figure 9

Regardless of their fish fillet ingestion rate, fish consumers can reduce their PCB exposure by selecting the younger, smaller fish of a species (within legal limits), removing the skin, belly fat, and internal organs prior to cooking, baking or broiling the fish fillet, and not eating the fatty juices or drippings.

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Appendix F— Response to Public Comments

ATSDR received several editorial comments on the public comment release of the Public Health Assessment for the Naval Weapons Station Yorktown, Cheatham Annex. Those comments were addressed in this version.

ATSDR also received some specific comments that are addressed below. We did not receive any comments from individual citizens or citizen groups.

Specific Comments:

The evaluation to "Potential Exposure to Contaminants Associated with the Penniman Shell Loading Plant" implies that additional investigations or remediation of that area is not necessary because there is limited contact with the area. High concentrations of metals and PAHs have been detected in some of these areas. In particular, lead concentrations in excess of 7,000 ppm were measured at the TNT graining house sump. ATSDR concluded that the levels would not be a concern because the area is heavily vegetated and exposure would be infrequent. However, if the area is developed in the future, these contaminants would be a concern as exposure becomes more frequent. VDEQ supports the cleanup of this area as part of the ongoing installation restoration program.

ATSDR modified the background portion of that section to include VDEQ's support of additional environmental investigations and remediation. ATSDR originally concluded that additional studies and/or remedial action could be necessary if redevelopment of that area was planned. ATSDR concurs with VDEQ that the concern is for future exposure to the contaminants of that area, whether on not the exposure results from redevelopment activities. Therefore ATSDR modified the discussion portion of that section and the conclusions to clarify that additional environmental investigations or remedial actions may be necessary if land use changes occur which allow greater public contact with the area containing the TNT graining house sump and catch box ruins.